Chapter 11: Surgical management of sinusitis

Valerie J. Lund

The majority of surgical procedures in the treatment of sinusitis were originally described in a pre-antibiotic era when rapid surgical intervention was often necessary to avert disaster. Today, although the operations remain the same, the indications for their use and the relative frequency with which they are required have altered. Acute sinusitis is now seldom a killer but chronic rhinosinusitis is common. Surgery for sinusitis aims to drain purulent secretions either by way of the natural ostium or more usually by the creation of an alternative drainage pathway which may be temporary or permanent. In so doing, complications are avoided and the sinus lining is given the opportunity to recover. When irreversible damage to the mucous membrane is deemed to have occurred, it may be removed completely and an attempt made to obliterate the sinus.

Embryological considerations (Schaeffer, 1920)

The maxillary sinus is first recognizable as a shallow groove expanding laterally from the infundibulum in the fourth intrauterine month. Extension laterally to reach the lateral cartilaginous plate is followed by absorption and expansion so that, at birth, the sinus has commenced invasion of the maxilla with its lower border about 4 mm above the nasal floor. Expansion and pneumatization continue until 8-9 years of age when the floors of the sinus and nasal cavity are roughly equal and the sinus 2 x 2 x 3 cm in dimension. Growth continues at the rate of 2-3 mm/year until the adult stage is reached when the sinus floor is usually lower than the nasal cavity (0.5-10 mm).

The ethmoids arise from preformed furrows between folds which develop on the lateral wall of the nose and are discernible in the fourth intrauterine month. The cells are primarily evaginations of nasal mucosa which grow into the lateral ethmoidal masses and, by further growth of the sacs and absorption of bone, become established as the cellular labyrinth which is well-pneumatized at birth. Up to the age of 6 years they grow slowly, but thereafter more quickly to reach their permanent shape by puberty.

The frontal sinus is absent at birth and only becomes obvious at 6-12 months of age. It develops:

(1) by direct extension of the whole frontal recess

(2) from one or more of the anterior group of ethmoidal cells arising in the frontal furrows associated with the frontal recess

(3) occasionally from the ventral extremity of the infundibulum ethmoidale by direct extension or from one of its cellular outgrowths.

Development often occurs from a combination of these origins but, in many instances, the frontal sinus is embryologically an anterior ethmoidal cell which has grown sufficiently far into the frontal region to be topographically a separate sinus. Extension into the horizontal portion of the frontal bone occurs first, followed by extension between the tables of the
vertical portion by simultaneous sinus growth and resorption of cancellous bone. This invasion is inconstant resulting in variation in thickness of the posterior wall and, although dehiscence in the bone of the walls are uncommon, the lamina papyracea and sinus floor are often thin. The sinus is usually fully developed by the age of 15 years.

The sphenoid is recognizable from the third intrauterine month as an invagination of the sphenoethmoidal recess. At birth it is 0.5 x 2 x 2 mm high and becomes fully aerated by the age of eight years.

As a consequence of this differential development, young children are potentially vulnerable to ethmoiditis, while later, the maxillary sinus becomes the most common primary site of infection, and frontal sinusitis is rare before puberty.

The maxillary sinus

Applied anatomy

The average dimensions of the adult maxillary sinus are 25-35 mm (breadth), 36-45 mm (height), and 38-45 mm (length) (Eckert-Mobius, 1954), with the natural ostium opening high on the lateral wall in the posterior infundibulum of the middle meatus.

Operations on the maxillary sinus must be examined in the light of certain anatomical considerations. The inferior meatus lies under the inferior concha and extends downwards to the floor of the nasal cavity. It is the largest of the three meatus and extends almost the entire length of the lateral wall of the nose. It is deepest at the junction of its anterior and middle thirds and the lower orifice of the nasolacrimal duct is found at this level (Gray's Anatomy, 1973). The inferior turbinate is attached in an arc with a maximum height range of 1.6-2.3 cm (mean 1.92 cm), 1.6 cm along the bony lateral wall. This constitutes the superior limit to any surgery in the inferior meatus. The nasolacrimal duct opens at or just anterior to the most cephalic portion of the inferior meatus, under the genu of the turbinate.

The thickness and quality of the bone alters within the meatus, with a gradual change from compact to lamellar bone superior to inferiorly and anterior to posteriorly so that the thinnest bone lies in the superior central portion of the meatus where it can be most easily perforated. The change in bone thickness inferiorly makes it progressively more difficult to cut down to the floor of the nose, while the thickness and decreasing meatal height preclude anterior surgical extension. This, together with the constant position of the nasolacrimal duct orifice, ensure that the duct opening is rarely damaged during surgery.

The blood supply of the inferior meatus derives primarily from the lateral sphenopalatine artery, which may be regarded as the terminal part of the maxillary artery. It passes through the sphenopalatine foramen into the cavity of the nose at the posterior part of the superior meatus. Here it gives off its posterior lateral nasal branches which ramify over the conchae and meatus, anastomosing with the ethmoidal vessels and the nasal branches of the greater palatine (Gray's Anatomy, 1973; Djindjian and Merland, 1978; Lasjaunias, 1981). A constant vessel arises from the lateral sphenopalatine artery, entering the inferior meatus posteriorly, and running superior to inferiorly at between 4 and 5 cm along the bony lateral wall. It then descends below the level of the palate, rising again very anteriorly on the lateral
wall. The surgeon's desire to avoid damage to this vessel together with changes in bone thickness and inferior meatal height limit the posterior extent of any surgical procedure.

The anterior superior alveolar nerve is derived from the infraorbital nerve and contributes to the superior dental plexus. The nerve is brought very constantly to the level of the anterior attachment of the inferior turbinate. At this point, branches pass inwards to the nasal chamber, inferior turbinate and meatus. A nasal branch which passes through a minute canal in the lateral wall of the inferior meatus supplies the mucous membrane of the anterior part of the lateral wall as high as the ostium of the maxillary sinus and the floor of the nasal cavity communicating with branches of the pterygopalatine ganglion (Gray's Anatomy, 1973). The distribution of this nerve demonstrates how changes in dental sensation can occur by direct trauma during inferior meatal surgery.

An explanation for paraesthesia following Caldwell-Luc procedures is readily apparent from an examination of the anterior surface of the maxilla. This displays a number of slight elevations overlying the roots of the upper teeth. Above and lateral to that of the canine tooth is the canine fossa in which the levator anguli oris is attached and which marks the natural point of entry into the maxillary sinus during a Caldwell-Luc procedure. Above the fossa is the infraorbital foramen, the anterior end of the infraorbital canal transmitting the infraorbital nerves and vessels.

The infraorbital nerves and vessels travel to the foramen initially in a sulcus which extends from the lateral portion of the orbital apex. Fifteen millimetres from the orbital margin, the infraorbital structures enter the canal which represents a constant thinning in the bone and which may be dehiscent. The orbital floor is thinnest along and medial to the sulcus, often 0.5-1 mm thick, affording a natural point of weakness between sinus and orbit (Lang, 1981).

**Historical review**

The first clear indication of the existence of the paranasal sinuses was provided by Berenger del Carpi, anatomist and surgeon at Bologna in the early sixteenth century (Wright, 1914). Fallopius (1600) referred to the maxillary sinus and suggested that the sinuses were absent in children until they reached maturity. Apart from the quotation: 'In a person having a painful spot in the head, with intense headaches, pus or fluid running from the nose removes the disease' (Hippocrates, 5th century BC), which may be inferred as describing sinus infections, the maxillary sinus and associated suppuration were not properly described until 1651 when they were reported by Nathaniel Highmore and for some time the sinus was referred to by this eponym.

The treatment of maxillary sinusitis by opening and irrigating the sinus via various routes has a long and varied history. Highmore himself advocated decompression by thrusting a silver bodkin through an empty tooth socket. Many of the earliest writers such as Cowper (1707) and Meibomius (1718) recommended irrigation through the alveolar tooth margin after moral tooth extraction, while Lamorier (1743) and Desault (1798) preferred the canine fossa approach. John Hunter (1835) was one of the first proponents of the intranasal approach and Zuckerkandl (1893) initially advocated perforation of the middle meatus, but later abandoned the technique because of the potential for orbital damage. The first description of the inferior
meatal antrostomy was probably by Gooch in 1770 (Cordes, 1905), but routine puncture of the inferior meatus was not common until advocated by Krause (1887), Mickulicz (1887) and Lichtwitz (1890). They used needle, trocar and stylette respectively. Thus began the first attempts at diagnosis by proof puncture followed by treatment by irrigation. In 1890 Lichtwitz invented the cannula which accompanied the perforating needle.

In his definitive paper on intranasal antrostomies Mikulicz (1887) described all the anatomical and physiological pitfalls of the operation. He realized that any perforation tended to close and felt that the cavity must be kept open to drain purulent secretions. Consequently, he recommended an antrostomy 5-10 mm in height, 20 mm in length and made flush with the floor of the nose.

Shortly after the introduction of the inferior meatal antrostomy, it was superceded by a more radical procedure described in 1893 by the American, Caldwell, in 1894 by Spicer from England and in 1897 by Luc from France, which differed from that advocated by Lamorier and Desault in that a counter-opening into the nose was included. Enthusiasm for the Caldwell-Luc procedure as the primary treatment of choice lasted throughout the early part of this century but, in the 1920s, a more conservative approach prevailed which meant that antral washout was succeeded by intranasal antrostomy via the inferior meatus and the Caldwell-Luc procedure only performed if that failed. This approach was supported by influential names such as Parker and Colledge (1921), Mackenzie (1927), St Clair Thomson (1926) and Negus (1958) and was facilitated by the advent of antibiotics.

An examination of the operative figures between 1950 and 1985 suggests that this trend is continuing despite a decline in the numbers of inferior meatal antrostomies from 1950 to mid-1960s. Since then the increase in antrostomies has occurred at a time when the Caldwell-Luc procedure has been decreasing in popularity and may be assumed to be at the expense of the more radical procedure. Furthermore, analysis of total numbers of operations suggests that this increase is genuine and not due to an overall increase in operating.

**Antral lavage**

**Indications**

Antral lavage has been used both in the diagnosis and treatment of sinusitis. Its diagnostic role has been to clarify radiological appearances by proof puncture. Therapeutically it is used in the treatment of acute and subacute maxillary sinusitis and pansinusitis which has failed to respond to conservative medication.

Antral puncture is usually performed through the inferior meatus. Sounding of the middle meatus to find the natural ostium is fraught with difficulties, not least the inability to find the ostium in 15-20% of cases (Van Alyea, 1936). The potential for orbital damage and the possibility of trauma and subsequent scarring of the ostium have precluded its use. Perforation of the anterior wall through the canine fossa for the introduction of a sinuscope represents a new facet to diagnosis as a more accurate form of 'proof puncture' (Chapter 3) and also offers a route for antral lavage.
Antral washouts may be performed at regular intervals, although opinion varies on the number and frequency of the puncture and on its efficacy, with some surgeons preferring to perform an inferior meatal antrostomy in the presence of pus and an obstructed ostium. An alternative method (Goode, 1970) is the insertion of an indwelling catheter through which daily irrigation can be performed until the quantity and quality of secretion improves.

**Table 11.1 Operations on the maxillary sinus and frontoethmoid region**

**Operations on the maxillary sinus**

Conservative
- antral washout
- intranasal antrostomy

Radical
- Caldwell-Luc
- Denker
- Canfield
- obliteration - McNeill

**Operations on the frontoethmoid region**

Conservative
- trephination of frontal
- intranasal ethmoidectomy
- transantral ethmoidectomy
- Jansen-Horgan

Radical
- external frontoethmoidectomy
- Lynch-Howarth
- Patterson
- Killian
- osteoplastic flap - Macbeth
- flap with obliteration - Goodale and Montgomery
- sinusectomy - Riedel.

**Contraindications**

The proximity of the orbital floor and teeth in the small maxillary sinus of children under the age of 3 years makes antral puncture hazardous and is, therefore, rarely performed. Similarly in the underdeveloped maxilla with thick bony walls, puncture may be technically difficult. Antral puncture and lavage is inadvisable in febrile acute maxillary sinusitis untreated by antibiotics because of the risk of osteomyelitis and septicaemia. In the presence of trauma which may have disrupted the orbital floor, antral washout is contraindicated and, if drainage of haematoma is deemed necessary, inferior meatal antrostomy is safer.

**Anaesthesia**

Antral washout can be performed under local or general anaesthesia.
Local anaesthesia

The nasal cavities are first sprayed with 10% cocaine and 1:1000 adrenaline solution and left for 3-4 minutes. This leads to shrinkage of the mucosa and facilitates insertion of cotton wool into the inferior meatus and drainage from the middle meatus through the natural ostium. Pledgets of cotton wool soaked in 10% cocaine and 1:1000 adrenaline solution can be placed along the inferior meatus and left for a further 4 minutes. Alternatively, 25% cocaine paste on silver wire wool carriers or Tumarkin wires can be placed in the nasal cavity, ideally one at the genu of the inferior turbinate and one approximated to the sphenopalatine ganglion at the posterior end of the middle meatus and turbinate.

Cocaine may cause adverse side-effects. Gastric absorption is more rapid than that from nasal mucosa so excessive cocaine trickling down the nasopharynx should be avoided. The maximal dose of cocaine for an adult is usually between 100 and 200 mg or up to 3 mg/kg. Malleable silver wires should be used in the nose, so that if the patient collapses this does not result in damage from wires being pushed through the cribriform plate.

General anaesthesia

This is rarely required for antral washout alone unless dealing with children or anxious adults. A cuffed oral endotracheal tube is employed and haemostasis and access facilitated by additional local anaesthetic vasoconstricting agents such as 25% cocaine paste, which can be spread with a cotton wool bud in the surgical field preferably with ECG monitoring. Moffat's solution can be instilled into the nose several minutes prior to surgery. This is composed of 4% cocaine solution, and 1% sodium bicarbonate in equal parts to 1/4 parts 1:1000 adrenaline.

Surgical technique

With the patient seated comfortably, the wool carriers or pledgets are removed and the inferior meatus visualized using a Thudicum speculum. A Tilley Lichtwitz trocar and cannula is used for puncture and it is advisable to check that the instruments match, engaging smoothly and with a sharp trocar end protruding 3 mm from the cannula. This is passed under the attachment of the inferior turbinate up to the genu where it will naturally come to rest. The instruments are held with the body of the trocar in the palm of the hand and the index finger running along its shaft so movement is controlled. Holding the patient's head steady, the trocar is directed towards the tragus of the homolateral ear.

Moderate pressure accompanied by a gentle boring action is usually sufficient to perforate the inferior meatal wall at its thinnest point. The trocar is advanced until it abuts the opposite antral wall and then withdrawn several millimetres. The trocar is then removed. The patient now leans forwards, holding a bowl beneath the chin to collect washings and is instructed to breathe through the mouth and to remark on any discomfort as lavage proceeds. The washout is performed using a Higginson syringe and sterile normal saline or water at 37°C. As fluid is flushed into the sinus the majority returns via the anterior nares, but any running posteriorly readily runs out of the mouth into the bowl. Washings can be inspected for the presence of mucus and sent for bacteriological and cytological examination. It may
be preferable to aspirate with an empty syringe before attachment of the Higginson apparatus to obtain an undiluted specimen.

If the procedure is performed under general anaesthesia, the patient may be placed in the tonsil position with a Boyle-Davis gag in place or with a head tilt of 15° and a throat pack. In either case, lavage is achieved with an ordinary hypodermic syringe containing 5-10 mL of fluid which is introduced and then aspirated to avoid unnecessary overflow into the nasopharynx. If the natural ostium is occluded, drainage may be facilitated by the introduction of a second cannula alongside the first. Excessive pressure should never be used. Care should also be taken not to introduce air during the procedure as fatal air embolus may result (MacNab Jones, 1976).

If a purulent washout is obtained, lavage should continue until it is clear. If the washout is initially clear, instillation should continue as mucoid material may require loosening. Following adequate lavage the cannula is withdrawn and the patient warned that fluid may continue to drain for the next few hours.

Complications

Mild haemorrhage may occur from the puncture site which can be stopped with 1 cm vaseline ribbon gauze packing for 12-24 hours during which time the patient must remain in hospital.

Incorrect positioning of the cannula should not occur if the technique described is followed. However, occasionally the anterior wall is breached leading to pain and swelling of the cheek. This is rapidly noticed in the conscious patient but, under general anaesthesia, requires observation and palpation. Similarly, perforation of the orbital floor leads to immediate pain. Under general anaesthesia, bulging of the orbital contents may be observed and for this reason the eyes are always left untaped and the upper lids gently lifted by an assistant. In the presence of a dehiscent infraorbital canal, even a correctly placed cannula can produce this complication. Excessive zeal on cannula introduction can also lead to perforation of the lateral or posterolateral wall, but is rare with controlled insertion. In all these circumstances, the procedure is abandoned and antibiotics given.

Inferior meatal antrostomy

Indications

This operation has been used in many forms of maxillary sinusitis, but is probably most successful in acute, recurrent or subacute sinusitis which has failed to respond to conservative medication, and usually one or two antral washouts. Although most commonly used in chronic sinusitis - by 78% of British otolaryngologists (Lund, 1986) - its success depends upon a return to normal of reversibly damaged mucous membrane by a combination of aeration and gravitational drainage. The degree of reversibility of the damaged mucosa will, therefore, determine the efficacy of the procedure.
Anaesthesia

Although the operation can be performed under local anaesthesia, general anaesthesia with cuffed oral endotracheal tube and pharyngeal pack is preferable. The use of a topical anaesthetic agent such as cocaine paste or Moffat's solution is useful in preparing the nasal mucosa prior to surgery.

Surgical technique

Many variations in technique are described and many alternative instruments may be used for each stage of the procedure.

The patient is prepared and towelled in a 15° head-up position and, under headlight illumination, the inferior turbinate is elevated with a Hill elevator. This instrument is then used to perforate the inferior meatus at the highest point under the genu of the turbinate. Enlargement is performed posteriorly with Grunwald nasal turbinate forceps, anteriorly with Seymour Jones antrum forceps and superiorly and inferiorly with a Hayek antrum punch forceps, either up- or down-cutting. The common use of the Ostrom forceps to cut anteriorly is not recommended as this instrument was designed for use in the middle meatus (Ostrom, 1913) and is vulnerable to breakage if used on the considerably thicker bone of the inferior meatus. Using an illuminated Killian speculum or headlight, the operation can be performed under direct vision.

Anatomical constraints limit the size of the antrostomy but, ideally, at least 2 cm x 1 cm windows should be fashioned to ensure long-term patency. Care should be taken to lower the inferior rim as much as possible to minimize the inevitable sump which results between floor of nasal cavity and that of the maxillary sinus. The edge of the antrostomy should be as smooth as possible with removal of free bone fragments and mucosal tags which predispose to infection and premature closure. Injudicious rasping of the edge is also not recommended. While discrete polyps can be removed via the antrostomy, blindly curetting with a Mackie curette is unwise. A sinuscope may be inserted via the antrostomy to inspect the antrum.

The use of rubber drains and packing into the antrum through the antrostomy is usually unnecessary, although a vaseline pack in the nasal cavity may be used for 24 hours. The inferior turbinate should be re-positioned at the end of surgery, although some surgeons prefer to trim a small anterior portion. The creation of a mucosal flap employing microsurgical techniques has been described (Reynolds and Brandow, 1975) but is of doubtful value. Suction cleaning and saline douching may be used postoperatively.

Complications

Examination of the anatomy of the inferior meatus readily demonstrates the potential complications of the operation. If the antrostomy is extended too far posteriorly the inferior meatal branch of the lateral sphenopalatine artery is encountered resulting in significant haemorrhage. Ordinarily haemorrhage from the antrostomy edge is not a problem.
Anterior extension may damage branches of the anterior superior alveolar nerve plexus leading to altered dental sensation, the incidence of which may have been underestimated in the past. Damage to the nasolacrimal duct orifice is fortunately rare due to its position and the quality of surrounding bone.

After initial fashioning all antrostomies undergo some circumferential closure due to healing, on average 0.4 cm. However, complete closure may be anticipated if an antrostomy is made 1 cm x 1 cm or less.

**Middle meatal antrostomy**

This operation has been advocated in the past (Lavelle and Spencer Harrison, 1969) but the potential for orbital damage and scarring of the natural ostium outweigh its possible physiological advantages. While the work of Hilding (1941) and Proetz (1941) demonstrated movement of ink particles by ciliary streaming towards the natural ostium irrespective of an antrostomy, the situation with damaged cilia and thick tenacious mucopus is clearly different and there is no doubt that secretions do drain through patent inferior meatal antrostomies.

**Caldwell-Luc procedure**

**Indications**

The operations aims to remove the irreversibly damaged mucosal lining of the maxillary sinus and facilitate aeration and gravitational drainage via an inferior meatal antrostomy. It is, therefore, reserved for chronic maxillary sinusitis and is most usually performed after the failure of conservative medication, antral washout and intranasal antrostomy. The cavity becomes partially obliterated by fibrous tissue which may confuse subsequent interpretation of sinus X-rays (Noyek and Zizmor, 1976).

In addition to its role in the treatment of maxillary sinusitis, there are a number of other situations in which this procedure is of value:

1. removal of foreign bodies, such as a root of a molar or premolar tooth or dental amalgam
2. inspection and biopsy of antral malignancy
3. closure of oroantral fistula
4. surgery for dental cysts involving the antrum
5. as part of the approach to the pterygomaxillary fissure and sphenopalatine fossa
6. removal of recurrent antrochoanal polyps
7. elevation and stabilization of orbital floor fractures (McNab Jones, 1976).
Contraindications

It is rarely performed in children, as damage to the secondary dentition may result.

Anaesthesia

While the operation may be performed under local anaesthesia (using a maxillary nerve block) it is most commonly carried out under general anaesthesia with a cuffed oral endotracheal tube and pharyngeal pack. The use of a topical vasoconstriction agent within the inferior meatus and injection of 1:200,000 adrenaline into the gingivolabial sulcus and soft tissues of the canine fossa is recommended.

Technique

The use of the headlight or illuminated speculum is usual with the patient positioned with 15° of head flexion. An incision is made down to bone in the gum margin, 3 mm above and parallel to the gingivolabial fold from the posterior edge of the lateral incisor to the first or second molar tooth (3-4 cm). It is advisable that the incision does not lie directly over the opening in the anterior face of the maxilla to lessen the risk of fistula.

The mucoperiosteal flap is then dissected superiorly with a periosteal elevator to expose the anterior wall of the sinus, taking care to avoid damage to the infraorbital nerve arising from the foramen just below the orbital rim. Retraction throughout the procedure should be as gentle as possible to avoid soft tissue swelling and paraesthesia.

The anterior wall is opened in the canine fossa where the bone is relatively thin. A 5 mm Jenkins gouge or drill may be used to make the initial entry and bone removed circumferentially with Hajek or Kerrison punch forceps to produce a circular opening approximately 1.5 cm in diameter. Inferior extension which may lead to damage of the teeth and their neural supply and lateral extension which may result in haemorrhage from the anterolateral terminal branches of the sphenopalatine artery should be avoided. Bleeding from the bony edge can be controlled by crushing the bone with punch forceps or diathermy.

The mucosa is then incised, the sinus inspected and the mucosa removed by careful elevation and dissection. Bleeding can be troublesome until all mucosa is removed and the success of the procedure depends upon complete exenteration of all diseased lining so that an uninfected fibrous membrane lines the sinus postoperatively. Particular attention should be paid to the inferolateral angle and roof which may be difficult to visualize.

A large inferior meatal antrostomy (2 x 1 cm) is fashioned as previously described, though the use of an inferiorly based mucosal flap is usually unnecessary. Packing the inferior meatus for 24 hours and even occasionally the antrum via the antrostomy is necessitated by significant haemorrhage though care must be taken on its removal to ensure no strands are caught on the bone of the edge of the antrostomy. Suturing of the buccal incision is recommended with absorbable suture material (to decrease the risk of fistula formation and obliteration of the labio-alveolar sulcus) but should be sufficiently loose to allow drainage of blood.
The patient should be advised against overenthusiastic blowing of the nose for at least a week and should replace upper dentures within 24 hours to avoid obliteration of the labio-alveolar sulcus.

**Complications**

Pain and soft tissue swelling are minimized by attention to surgical technique. Haemorrhage can occur from both the anterior bony wall or inferior meatal antrostomy but is usually controlled by packing.

Paraesthesia due to damage of the infraorbital nerve may be temporary or permanent but should be avoided by careful dissection and retraction. Damage to the teeth apices and their innervation may lead to alteration in dental sensation and very rarely devitalization and discoloration of the tooth.

Oroantral fistula may occasionally occur particularly if care is not taken with the siting of the incision. The fistula may be temporary or permanent requiring surgical intervention later. Osteomyelitis of the maxillary bone is more a theoretical than a real complication these days.

*Modifications of the Caldwell-Luc operation*

**Denker's procedure (1906)**

This allows access to the nasal cavity and maxillary sinus simultaneously by continuing the incision medially to the frenulum. It is in other respects very similar to the Caldwell-Luc operation.

**Canfield's operation (1908)**

An intranasal incision is made just behind the vestibule. The periosteum is elevated laterally over the edge of the pyriform aperture and into the canine fossa. This anterior angle of the maxillary sinus is chiselled off to expose the antral contents and then the opening is continued posteriorly into an intranasal antrostomy.

**Maxillary sinus obliteration (McNeill, 1966)**

The variable success of the intranasal antrostomy and Caldwell-Luc operations and the interest in oblitative procedures in the frontal sinus led McNeill to describe an operation of maxillary sinus obliteration based on experimental work in cats.

Through a sublabial approach, an inverted U-shaped flap is drilled in the bone of the anterior maxillary sinus. The mucous membrane of the sinus is removed completely and the exposed bony surface burred with a drill. The cavity is then filled with abdominal fat. Considerable success was claimed for the procedure, but it is rarely performed today.
The frontoethmoidosphenoidal complex

Applied anatomy

The skull contains only one ethmoid bone in the form of a cross which provides the central support for the anterior cranial fossa. The crista galli protrudes above the horizontal bar and the perpendicular plate below. At either end of the horizontal bar are the lateral air cell cavities or labyrinths. The whole bone is 2.5 x 2.5 x 2 cm in the adult, and is pyramidal in shape with the apex pointing anteriorly and the base abutting the sphenoid so that the posterior wall of the last ethmoidal cell forms the anterior face of the sphenoid (Ritter, 1982).

A plane of bone, the basal lamella, traverses the entire labyrinth, medially giving attachment to the middle turbinate and laterally abutting the lamina papyracea. The lamina papyracea forms the lateral wall of the air cells and part of the medial wall of the orbit and is extremely thin. Superiorly, the thin fovea ethmoidalis bone separates brain from air cells.

The middle turbinate lies inferomedial to the ethmoid mass. The anterior end is broad and often contains an air cell, the posterior end is narrow with the bone attached to the basal lamella. The middle turbinate and its basal lamella divide the ethmoid into anterior cells (2-8) draining mainly into the anterior infundibulum of the middle meatus and the posterior cells (1-7) draining into the superior meatus. Another important anatomical relationship, apparent in the coronal section, is that of the middle turbinate to the floor of the orbit which lies level with the midpoint of the turbinate.

In an anterior coronal section, the middle turbinate lies inferior and medial to the air cells but as one progresses posteriorly, this relationship changes so that the middle turbinate comes to lie more inferiorly and less medially with the result that the bone lateralizes as one progresses backwards. Because of the alteration in the relative position of the middle turbinate it may not always be a reliable landmark and it has been suggested (Ritter, 1978) that the bone of the middle meatus itself is preferable as staying medial to this ensures the safety of the lamina papyracea. It should be further realized that all ethmoidal cells except the most posterior lie medial to the medial wall of the maxillary sinus. While anterior contact between antrum and ethmoidal block is just a few millimetres, the larger posterior ethmoidal cells are in contact with more of the medial superior surface of the maxillary sinus.

On coronal sections it is evident that the lamina papyracea in the vertical plane is in line with the medial wall of the maxillary sinus. Of significant clinical relevance is the way in which the lamina papyracea curves 2-3 mm medially as it courses from the apex of the orbit anteriorly rendering the orbital contents more vulnerable than is appreciated. In addition, the solid bone of the greater wing of the sphenoid can be pneumatized by ethmoid cells.

Bearing in mind this anatomy, it becomes evident that it is impossible to exenterate all cells from below without jeopardizing the orbit, rendering both intranasal and transantral approaches intrinsically inadequate for complete ethmoidal exenteration. Pathologically, the thickness of the medial wall provides little anatomical barrier to infections of the ethmoid with the resultant clinical complications of orbital cellulitis, orbital abscess, optic neuritis and cavernous sinus thrombosis (Jarrett and Gutman, 1969; Schram, Curtin and Kennerdell, 1982).
The applied anatomy relevant to the external ethmoidectomy approach requires separate consideration. The subcutaneous tissues are very vascular and significant bleeding often occurs from branches of the supratrochlear artery and angular vessels. A definite single cut down to bone through the soft tissues will expose and facilitate clamping of these bleeding vessels.

The periosteum should be incised and elevated with care, particularly where it is adherent to the frontonasal and frontoethmoidal sutures to avoid damage to the trochlea. Similarly, when dissecting periosteum from the medial orbital wall, care should be taken as tearing the periosteum leads to troublesome prolapse of orbital fat into the surgical field.

The anterior and posterior ethmoidal vessels are encountered as periosteal dissection continues and provide important landmarks to the level of the cribriform plate and dura of the anterior cranial fossa. The posterior ethmoidal artery, in addition, lies 3-8 mm anterior to the optic nerve in its foramen. The rule of 24-12-6 may be applied to the medial wall of the orbit, representing respectively, the average distance in millimetres from the anterior lacrimal crest to the anterior ethmoidal foramen, from anterior to posterior ethmoidal foramen and from posterior ethmoidal foramen to optic canal (Rontal, Rontal and Guilford, 1979). The situation can, however, be very variable, with 16% of patients having no anterior ethmoidal foramen and 30% multiple ethmoidal foramina (Harrison, 1981).

Once the ethmoidal system is opened, it should be remembered that the middle turbinate, while not infallible, still represents an important landmark particularly to the cribriform plate; removal of the turbinate makes revision procedures particularly hazardous. It is, therefore, recommended that it is retained at least until the end of the operation. The close proximity of the cribriform plate makes it vulnerable to damage (both iatrogenic and pathological) leading to cerebrospinal fluid fistula. In addition, tubes of dura on fibres of the olfactory nerve running to the superior part of the lateral wall of the nose can be damaged leading to a similar complication.

The frontonasal duct is frequently damaged by disease and surgery in this region. To ensure patency and decrease the potential for subsequent mucocoele formation, it is advisable routinely to open into the frontal sinus and remove the medial part of the sinus floor and, in certain circumstances, to create an artificial frontonasal duct with Silastic tubing.

The frontal sinus is radiologically recognizable in 50% of subjects by the age of 6 years and fully developed by 15 years of age although 1-2% remain undeveloped (Schaeffer, 1920). Greatest variation in size occurs in the frontal sinus with a range of 28.95 ± 8.62 mm breadth, and 20.5 ± 7.74 mm in sagittal length, but maximum dimensions of 49 mm and 45.5 mm respectively have been reported in one study (Lang, 1981). The sinus is often divided into two parts, a transverse part which grows into the orbital roof and a vertical part which develops upwards within the squamous portion of the frontal bone and comes to lie in the front of the floor of the anterior cranial fossa. Separate pneumatization of the horizontal portion is often overlooked in operative procedures owing to its depth from the frontal region.

The sinus may be compartmentalized by incomplete bony septa, but a complete intersinus septum is usually present though often situated in a paramedian position.
Supernumerary sinuses are extremely common and normally drain independently by separate ostia communicating with the frontal region of the middle meatus. In addition, not infrequently, anterior ethmoidal cells encroach on the floor of the frontal sinus ballooning up into the lumen. They may arrange themselves in tiers and encroach upon the frontonasal duct. Finally, diverticula can bud off from the sinus at an early stage, remaining in communication with the parent sinus but again easily overlooked at surgery.

Considerable variation exists in the manner by which the sinus communicates with the nasal cavity and is directly related to the embryology. When it arises as a direct extension of the whole frontal recess, it may open by an ostium into the anterior part of the middle meatus. When the sinus arises from one of the furrows or from one of the cells of the infundibulum, a frontonasal duct is present. Consequently, the sinus may drain via the duct alone, separate from the infundibulum ethmoidale or partly by both routes. The length, diameter and tortuosity of the duct varies considerably and in those with a long serpentine course and encroached upon by a neighbouring ethmoidal cell, the slightest swelling of the mucosa will cause occlusion. In its terminal portion, other structures may impinge such as an asymmetrical nasal septum, enlargement of the uncinate process and ethmoidal bulla or a large middle turbinate.

Venous drainage is normally along the frontonasal duct mucoperiosteum to the veins of the nasal cavity but, in addition, veins from the frontal sinus, in the vicinity of the trochlear fossa pass through small bony foramina into the orbit, connecting with the superior ophthalmic venous system.

The relative thickness of the bony walls determines where empyemas of the sinus most frequently rupture. This tends to be the floor and lower anterior wall just above the medial canthus, although in large sinuses, rupture can occur high on the forehead.

The sphenoid, in addition to its main cavity, which in the adult measures 14 x 14 x 12 mm, may also have diverticula. This may lead to pneumatization of both the greater and lesser wings and even of the pterygoid plates. As a consequence, a variable amount of pituitary fossa is exposed to the sinus lumen and in large sellar sinuses the internal carotid and adjacent nerves form obvious grooves with only a thin intervening layer of bone. even when the sinus is small, the superior wall is usually the thinnest (1 mm) rendering the optic chiasma vulnerable to penetration of the walls with surgical instruments. The posterior wall, although thin, can usually be directly visualized while the inferior wall is relatively thick.

The ostium is located one-half to one-third the distance up the face of the sphenoid, usually 2-5 mm from the dura and the same distance from the midline. The intersinus septum is always thin and often asymmetrically placed leading to unequal cavities.

**Historical review**

From the outset, operations on the frontoethmoidal complex fell into two groups (Macbeth, 1954): those designed to enhance drainage while preserving facial contour; and those aimed at eradicating irreversibly diseased mucosa disregarding cosmesis. As with the maxillary sinus, initial surgical treatment of infection concentrated on opening and draining the frontal sinus by trephination (Wells, 1870; Ogston, 1884). Ogston described a midline
vertical incision, using a trephine about 1 cm in diameter, followed by enlargement with a chisel, removal of the mucous membrane and insertion of a drainage tube into the nose. A more extreme procedure was suggested by Riedel in 1898 in which the inferior and anterior walls were removed leading to severe cosmetic deformity.

To overcome some of these problems, Killian (1903) proposed removal of the anterior and inferior walls but preservation of supraorbital bridge. Later he extended dissection to include the frontal process of the maxilla to facilitate drainage through the anterior ethmoidal cells and this procedure remained popular during the beginning of the twentieth century. An alternative approach was described by Lothrop (1915) who suggested circumventing the frontonasal duct on the diseased side by removing the intersinus septum, thereby converting the frontal sinus into one single cavity draining into the nose.

The Killian procedure was criticized by the advocates of 'external ethmoidectomy' as it left a 'dead space' (Howarth, 1921), the frontonasal duct region frequently closed and the ridge of bone often sequestrated (McNally and Stuart, 1954). Jansen (1902) had proposed removal of the frontal sinus floor, but with preservation of the anterior wall. His operation included exenteration of the adjoining ethmosphenoid system and was modified and popularized by Howarth (1921) in the UK and Lynch (1921) in the USA. Their operation which included removal of all frontal sinus mucous membrane, dealing with any intranasal obstruction and antral disease with the creation of an enlarged frontonasal drainage via an ethmoidectomy, dominated the first half of the twentieth century.

Mosher (1913) is credited with the first description of an intranasal ethmoidectomy, based on careful anatomical studies. Since then discussion has centred around preservation or removal of the middle turbinate. Skillern, following Mosher, removed the turbinate to enhance ventilation (1928), whereas Pratt (1925) advocated its preservation, a view which most practitioners have endorsed, although dissatisfaction with the procedure and its dangers have led to increasing use of the external approach (Eichel, 1979).

Smith (1934), Sewall (1935) and Negus (1947) added their support for the external approach, although some differences existed between the methods described. Both Lynch and Smith insisted on the importance of removing all mucous membrane, while Howarth and Negus suggested that mucosa should be preserved where possible. Lynch, Sewall and Smith advocated removal of all the sinus floor; Howarth initially supported this but on later review (1936) felt it was not essential, a view which Negus endorsed (1947). Lynch and Negus recommended the concomitant treatment of antral disease while little mention of this is made by Howarth, nor did he consider sphenoidal drainage, which was felt to be important by Lynch, Sewall and Smith. Finally, Lynch suggested that exenteration of the anterior ethmoidal cells would provide adequate frontonasal drainage, Sewall suggested a mucoperiosteal flap from the middle turbinate while Smith, Howarth and Negus preferred a split skin graft and rubber tubing as a stent.

There followed further attempts to preserve the frontonasal duct with exogenous material such as tantalum (Goodale, 1945) or acrylic obturators (Erich and New, 1947) with more recent interest in the mucoperiosteal flap (Ogura, Watson and Jurcina, 1960; Baron, Dedo and Henry, 1973). However, a high recurrence rate of problems led Boyden (1952) to conclude that the efforts to preserve the frontonasal duct were the chief cause of failure and
resulted in the emergence of the osteoplastic flap as the definitive operation for chronic frontal sinus problems.

Originally described by Schonborn (1894), Briegar (1895) and Winckler (1904), the operation was championed by Gibson and Walker (1951) and Macbeth (1954) in the UK and Bergera and Itoiz (1958) and Goodale and Montgomery (1958) in the USA. Macbeth believed that obliteration of the sinus, once it was stripped of its mucosa would occur naturally with fibrous tissue and bone as supported by the experimental work of Samoilenko (1913), Walsh (1943), and McNeill (1966). However, without complete removal of all the mucous membrane, obliteration might be incomplete and consequently obliteratorive procedures were devised using both exogenous and endogenous material. The use of exogenous material was largely unsuccessful (Schenck, 1975) and it was superceded by the use of endogenous substances such as abdominal fat (Goodale and Montgomery, 1958; Bergara and Itoiz, 1958). It is worth noting that Kuhnt described obliteration of the frontal sinus in 1895 and referred to Runge who performed a similar procedure 100 years earlier!

The decreasing incidence of chronic frontal sinusitis, the over-estimation of recurrence associated with the Lynch-Howarth technique and undoubted cosmetic problems of the osteoplastic flap together with the risk of infection both at the primary and donor fat site in obliteratorive procedure has led to a swing back to the Lynch-Howart operation in the UK, while the osteoplastic flap continues to be popular in North America (Rubin, Lund and Salmon, 1986).

**Intranasal ethmoidectomy**

**Indications**

The usual indication for this procedure is chronic sinusitis in association with nasal polyposis. It provides an inadequate approach for complete exenteration of the ethmoid complex but may be a preliminary procedure for more extensive external surgery. The operation aims to restore normal function while maintaining normal nasal anatomy by exteriorizing the ethmoid labyrinth into the superior nasal vault.

**Contraindications**

The procedure has become less popular, with fewer exponents familiar with the surgical anatomy which in turn leads to less usage. It is difficult to teach and is particularly hazardous in the presence of previous ethmoidal surgery. It should be very carefully considered when operating in the region of the only seeing eye.

**Surgical technique**

The operation is best performed under general anaesthesia with topical vasoconstrictors to achieve haemostasis. A reversed Trendelenburg position is preferred.

If the operation is being performed for nasal polyposis, it is better to attempt to clear the polyps intranasally to gain access. Similarly it may be necessary to out-fracture the inferior turbinate, and in-fracture and remove the first centimetre of the middle turbinate.
Using a long-bladed Killian speculum, the ethmoids may be entered just lateral to the anterior tip of the medial wall of the middle turbinate and the area cleared superiorly using a Tilley Henckel forceps, until the hard white bone of the fovea ethmoidalis is seen. The forceps must always be used with the opening blade directed medially, away from the lateral wall.

The position of the lamina papyracea may be determined by placing the forceps intranasally and a finger on the outer side of the lacrimal bone at the medial canthus of the eye. The ethmoidal labyrinth may then be exenterated, using the middle turbinate as the medial boundary and working with back-biting forceps towards the ascending process of the maxilla. The middle turbinate should be preserved as a landmark for as long as possible. Adrenaline-soaked ribbon gauze may be used during the procedure to maintain adequate haemostasis.

The surgeon should constantly watch for the appearance of yellow orbital fat in the surgical field and should consistently avoid directing any instrument laterally when 5 cm or greater from the inferior alar rim of the nasal vestibule to avoid damage to the optic nerve. The sphenoid may be entered by this approach. Displaced turbinates may be repositioned and the nose packed.

In summary the following rules should be applied to surgery in this area (Jafek, 1985):

1. avoid the cribriform plate by not going superior to the medial canthal ligament
2. avoid the orbit by not going lateral to the medial canthal ligament
3. always curette downwards, anteriorly and medially
4. examine all material removed for the presence of orbital fat
5. operate only under direct vision.

Complications

Injury to the lamina papyracea may lead to haemorrhage. This in turn may lead to intraorbital but extraperiosteal bleeding with anterior tracking producing a periorbital haematoma (Harrison, 1981), erroneously considered by some as the hallmark of a successful operation. Posterior tracking of the haematoma leads to proptosis and visual loss, necessitating removal of nasal packing or exploration (Leopold, Kellman and Gould, 1980). Direct injury to the orbital periosteum may lead to fat prolapsing into the surgical cavity which can be packed with gelatin sponge.

Dural injury via the cribriform plate can lead to cerebrospinal fluid leak which, if noticed peroperatively, can be packed with fascia lata or muscle and Whitehead's varnish pack, treated with appropriate antibiotics and the patient nursed sitting up. If this is unsuccessful, it is possible to explore the area and use a septal mucosal flap to plug the dehiscence.

Despite precautions, blindness and meningitis are possible consequences of the operation and careful monitoring of the patient must be instituted postoperatively.
Transantral ethmoidectomy - Jansen Horgan procedure (1902, 1926)

Indications

The operation is used in combination with the Caldwell-Luc procedure for chronic inflammation and infection affecting the maxillary sinus and ethmoidal cells. It has also been used as a route for orbital decompression in 'malignant' exophthalmos.

Contraindications

The operation is only of use when complete exenteration of the ethmoids is not required.

Surgical technique

After performing a routine Caldwell-Luc approach, the posterior cells are opened through the antrum by pushing a closed Tilley Henckel forceps upward, medially and posteriorly at the upper and inner angle of the antrum, towards the opposite parietal eminence. If the natural ostium of the maxillary sinus can be located, the ethmoidal bulla lies immediately superior to it. The opening is enlarged with punch forceps and the posterior and middle cells exenterated employing the usual precautions with regard to the cribriform plate and orbit. The anterior wall of the sphenoid can be identified and opened. The anterior and agger nasi cells can only be reached safely if the operation is combined with an intranasal ethmoidectomy.

Complications

These are similar to those for an intranasal ethmoidectomy, that is haemorrhage and orbital trauma.

External frontoethmoidectomy

Indications

By combining a transorbital with a transnasal approach, this procedure offers access, illumination and perception of depth which obviates many of the disadvantages inherent in less 'open' operations. It aims to convert the ethmoid labyrinth into a single cavity and is useful in a number of circumstances:

(1) chronic infection unresponsive to conservative medication

(2) complications of acute ethmoiditis such as orbital cellulitis in which it is a useful approach for decompression and drainage

(3) recurrent polyposis, especially when previous intranasal surgery has been employed destroying useful landmarks
(4) in combination with the surgical exploration of the frontal sinus in mucocoele formation

(5) as a means of access in ethmoidal artery ligation for epistaxis, transethmoidal hypophysectomy, dacryocystorhinostomy, repair of cerebrospinal fluid leaks and decompression of malignant exophthalmos

(6) it has no place alone in the definitive oncological treatment of sinus malignancy except for occasional diagnostic purposes and has been superceded by the craniofacial operation in this area.

**Lynch-Howarth procedure**

The operation is best performed under general anaesthesia via an oral tube, with pharyngeal pack and the application of topical vasoconstrictors. The patient lies in the reversed Trendelenburg position, with 15° head flexion. A temporary tarsorrhaphy should be performed initially to protect the eye.

The incision is made slightly curved medial and concave towards the medial canthus of the eye, straight down to bone. The incision may be extended under the eyebrow to facilitate access to the frontal sinus. Bleeding from the angular vessels is often encountered. The peristomeum is elevated with care to reveal the nasal process of the maxilla, frontal bone and medial wall of orbit. The lacrimal sac is elevated and displaced laterally.

Dissection continues posteriorly to reveal the anterior ethmoidal vessels which are ligated with sutures or neurosurgical clips or coagulated with bipolar diathermy. The posterior ethmoidal vessels approximate to the posterior limit of the ethmoidal cells and are also ligated. Dissection is aided by the use of 1 cm ribbon gauze soaked in topical adrenaline and retraction is best performed with a malleable copper probe.

The thin medial wall of the orbit is perforated with ease, exposing the ethmoidal cells which may be progressively exenterated under direct vision, bearing in mind the level of the cribriform plate. Thus the middle turbinate and middle meatus can be defined both intranasally and externally. It is important that exenteration continues up to and including the sphenoid and that all diseased mucous membrane is removed. Similarly it is important to open into the frontal sinus, the medial floor of which will be approached via the anterior ethmoidal cells. The amount of frontal sinus floor removed will depend on the access required and the extent of disease in the frontal sinus. The diseased lining mucosa should be removed completely, bearing in mind the variable anatomy of the sinus.

It is important to establish and maintain patency of the frontonasal region and to this end a fenestrated Silastic tube, 1 cm in diameter, is placed from the frontal sinus, through the ethmoidal region to open in the nasal cavity. The length of time that the tube must be left *in situ* has yet to be established but 3-5 months would seem reasonable and allows the establishment of a permanent patent channel. Attempts to reconstruct the frontonasal region by the use of mucoperiosteal flaps and split skin grafts are unnecessary, fraught with failure and obviated by this technique.
The periosteum, subcutaneous tissues and skin are sutured carefully with catgut and silk and a pressure dressing applied for 24 hours. The skin sutures can be removed at 4-5 days.

**Complications**

Problems may result from the incision itself, including oedema and infection, paraesthesia of the skin, damage to the medial palpebral ligament and webbing of the wound. This cosmetic deformity has been made much of in the American literature, but careful placement of the incision renders it a minor problem (Rubin, Lund and Salmon, 1986).

Haemorrhage can occur per- or postoperatively associated with retraction of the ethmoidal vessels before adequate haemostasis is achieved but it is usually self-limiting.

Dural exposure, either surgically or by the pathology itself is not uncommon, but any evidence of a cerebrospinal fluid leak should be treated with the appropriate antibiotic and closure of the defect primarily with fascia lata, tissue glue, Gelfoam or a septal mucosal flap.

Significant damage to the periorbita should be repaired immediately to avoid prolapse of orbital fat into the surgical field. Periorbital swelling is minimized with a pressure dressing and any resultant epiphora and diplopia are usually transient. Diplopia may also result if the globe is decompressed surgically after accommodating to long-term displacement. The eye should be washed with saline at the end of the procedure to remove blood, and Chloromycetin ointment instilled to prevent conjunctivitis.

Serious visual loss is unusual but can obviously result if the globe is injured and is a theoretical complication of sudden decompression after long-standing displacement, and may be treated with prophylactic use of steroids.

Failure to maintain the patency of the frontonasal duct may be associated with subsequent mucocoele formation (Schenck, 1975) and the original disease process may recur, which has led to the operation being supplanted by the osteoplastic flap in the USA.

**Transorbital ethmoidectomy**

**Patterson's operation (1939)**

The indications for this operation are similar to those for the Lynch-Howarth procedure but, in addition, it allows access to the orbital floor which is of use in orbital trauma or decompression and for transethmoidal hypophysectomy.

The incision, 2 cm long, is made in the natural crease line, one finger's breadth below the inferior orbital margin. The orbicularis muscle is split and the periosteum incised and elevated to the orbital margin. Once again, meticulous care is needed to avoid tearing the periosteum, and the origin of the inferior oblique muscle (except in 9% of patients where this muscle is intraperiosteal) is eventually revealed and, medially, the lacrimal sac (Harrison, 1981). As dissection advances, this gap opens to reveal the orbital floor and medial wall as far posteriorly as the posterior ethmoidal foraminae. Mobilization of the lacrimal sac provides
access to the anterior ethmoidal cells and removal of the lamina papyracea is performed under direct vision. This is continued until the compact bone of the sphenoid surrounding the optic canal is seen, when further removal of ethmoidal cells is carried out transnasally. Again it is important to open into the sphenoid sinus and the frontal sinus may also be entered through this approach though with less ease than with the Lynch-Howarth operation.

Complications are similar to those for the Lynch-Howarth procedure with recurrence of disease and transient epiphora associated with oedema of the orbicularis fibres being the commonest.

The frontal sinus

Frontal sinus washout

Indications

This procedure is performed when acute suppurative frontal sinusitis has failed to respond to antibiotics (oral and parenteral), decongestants and topical vasoconstrictors. Following the surgical principle of draining pus under pressure, it aims to avoid mucosal necrosis, osteomyelitis and intracranial complications. It should be done only after adequate antibiotic treatment has been instituted but should not be delayed if the situation is deteriorating or fails to resolve rapidly.

Contraindications

Radiological examination to establish the existence and extent of the frontal sinus should precede any surgery in this region.

Surgical technique

The operation is performed under general anaesthesia, in the reverse Trendelenburg position, with an oral tube and pharyngeal pack. A temporary tarsorrhaphy protects the eye. An incision is made 1 cm below the medial end of the eyebrow, straight down to bone. The sinus is usually entered with ease, using a small gouge and hammer or drill and the purulent contents released. The entry hole is enlarged with Citelli or Hayek punch forceps to allow adequate visualization of the sinus and a drainage tube is inserted and sutured in place.

In the presence of a pansinusitis, which is commonly the case, antral lavage may be indicated and, postoperatively, intravenous antibiotics should be continued in combination with regular frontal sinus washout. When the washout return is clear, and fluid begins to appear in the nose, suggesting restored functioning of the frontonasal duct, the drainage tube can be removed. Failure of normal drainage to be re-established may necessitate further surgical intervention such as external frontoethmoidectomy.
Complications

Careful placing of the incision avoids damage to the trochlea, supraorbital and supratrochlear nerves. Care should also be taken with anteriorly placed dura in sinuses which may have dehiscent bony walls.

Osteoplastic flap procedure

Indications

The procedure is primarily designed for conditions of chronic suppuration which have failed to respond to all other means of treatment. It has been used as an approach for osteomata, for the repair of trauma to this region, and in the treatment of frontoethmoidal mucocoeles.

Contraindications

If the ethmoids are extensively involved, it can be difficult to gain adequate access to this region via the osteoplastic flap approach alone.

Preoperative preparation and surgical technique

X-rays of the frontal region are taken to determine the extent of the sinuses and the pathological changes. From the X-ray, a template can be made to be used during the operation. Silastic sheeting may be used which can be sterilized preoperatively. Bacteriological cultures from the nose should be taken and the appropriate prophylactic antibiotics given with premedication.

The skin should be shaved 4 cm back from the hairline and prepared with aqueous Hbitane. If obliteration is to be performed, the abdomen must also be prepared. The operation is performed under general anaesthesia, in the reversed Trendelenburg position. The head should be positioned so that the plane of the forehead is horizontal. Temporary tarsorrhaphies are performed and infiltration with lignocaine and adrenaline is helpful.

A coronal incision is made, through the skin, subcutaneous tissue and frontalis muscle, behind the hairline, but taking care not to incise the periosteum, and the flap elevated inferiorly in the plane between the frontalis muscle and the periosteum down to the supraorbital rims and glabella. Neurosurgical clips are useful for haemostasis and the incision is extended inferiorly to a point just anterior to the root of the helix to provide wide exposure.

The sterilized template is then placed over the frontal sinuses, aligning the supraorbital rims exactly and the superior and lateral margins of the sinus are marked with methylene blue. The periosteum may then be incised along this line down to bone. It is advisable to elevate the periosteum for 2-3 mm on each side of the incision to facilitate closure.

Using a fissure burr or oscillating saw, a cut is made round the outline, cutting just inside the line to ensure the incision is within the limits of the sinus and bevelling it obliquely to prevent the bone falling in on the replacement. The entire margin is cut around, including
the supraorbital rims and glabella. It is often necessary to cut through the intersinus septum with a chisel to free the anterior wall which can then be prised down and forwards, so that the osteoplastic flap is hinged along the floor of the frontal sinus just posterior to the supraorbital rim.

All diseased tissue can be removed and the mucosa stripped completely. The bone should then be burried to remove all traces of mucous membrane and the last vestiges inverted into the frontonasal duct to obliterate it. If an attempt is to be made to obliterate the sinus, fat from the left lower quadrant of the anterior abdominal wall is removed and must be handled with care to avoid trauma. (The right side is avoided so that it cannot be mistaken for an appendicectomy scar at a later date.) The abdominal wound is closed in layers after achieving haemostasis. The fat is placed in the sinus cavity and should fill it completely.

The bony flap is replaced, and the periosteal layer repaired meticulously to avoid cosmetic deformity. The skin is sutured in two layers and a pressure dressing applied for 24 hours. An alternative incision can be made just superior to the eyebrows and connected across the glabella. This is suitable when the sinus is small, and on no account must the eyebrows be shaved. The preceding description applies to the operation for bilateral disease, but it is possible to open one sinus alone by cutting parallel and lateral to the intersinus septum, the position of which can be determined from radiography. It is, however, rarely employed.

Complications

Cosmetic problems associated with the incision and repair are not uncommon and haematoma collection under the flap may occur. Frontal bossing, bony depression and nasal skin necrosis have been reported (Sessions et al, 1972; Ward and Bauknight, 1973; Schenck, 1975; Hardy and Montgomery, 1976) and may necessitate subsequent cranioplasty and bone grafting. In middle-aged men with receding hairlines even the best scar may become obvious with time. Osteomyelitis can develop in the frontal bone flap and both the primary and donor site wounds can be infected. The dura may be torn if the template is incorrectly drawn or copied leading to a cerebrospinal fluid leak and, as with all operations for sinusitis, the possibility of recurrence of the original pathology has been reported as high as 25% (Schenck, 1975).

Radical frontal sinus procedures

Fortunately there is now little place for the more radical frontal sinus operations. The removal of the anterior sinus wall and floor in sinusectomy as described by Riedel (1898) leaves considerable disfigurement, particularly when the sinuses are large and, although attempts have been made to correct this with acrylic implants (Ritter, 1978; Barton, 1980), these are often unsuccessful due to rejection in the presence of continued infection.

Sphenoid sinus operations

The sphenoid sinus is rarely infected alone. As part of a pansinusitis it can be drained intranasally, directly or via an intranasal ethmoidectomy. Direct cannulation of the sphenoid ostium can be done with a sphenoid cannula (10 cm length) introduced along the nasal septum towards the end of the middle turbinate, making approximately a 30° angle with the floor of
the nose. By gentle manipulation it may be possible to enter the ostium and irrigate carefully with warm saline. More usually the sphenoid is opened during an external frontoethmoidectomy. The most frequent requirement for sphenoid sinus exposure is in the approaches to hypophysectomy (Chapter 21).

**Choice of treatment in sinusitis**

A wide range of procedures is available in the treatment of sinusitis and the choice of operation must be tailored to the requirements of the individual patient and the experience of the surgeon. In acute sinusitis when conservative measures fail, the surgical principle of drainage of pus is implemented to achieve rapid resolution and avoid serious complications. It is when the condition is recurrent or persistent that the selection of a surgical approach is more difficult. The multiplicity of these approaches indicates the intrinsic inadequacies inherent in the treatment of chronic sinusitis and while the progression through increasingly more radical procedures is not to be deprecated, it may be that our failure to deal adequately with chronic sinusitis is due to the use of operations which depend on a return to normal of irreversibly damage mucosa.

In the case of maxillary sinusitis, after an adequate course of broad-spectrum antibiotics and decongestants, antral lavage is often effective. How often this should be repeated before proceeding to further surgery is debatable and there has been a move towards earlier surgical intervention as compared with the once traditional 'weekly washout'. To establish better drainage other procedures such as submucous resection of the nasal septum and removal of nasal polyps, must also be considered.

The purpose of the inferior meatal antrostomy is presumed to be a combination of aeration and gravitational drainage which facilitates a return to normal or reversibly damaged mucous membrane. The operation should, therefore, be implemented at an early stage. To achieve long-term patency of the antrostomy, it is necessary to aim at a 2 x 1 cm window in an adult with careful attention to technique, but it is difficult to evaluate the clinical effectiveness of the procedure as many patients undergo cyclical improvement and deterioration of their symptoms without any appreciable alteration in antrostomy size. Indeed, it may not matter if the antrostomy does close.

The problem lies in the inability to quantify accurately the degree of mucosal damage and, therefore, the decision to implement a Caldwell-Luc operation is often an arbitrary one, usually based on clinical failure of the antrostomy.

In infections of the ethmoid and sphenoid sinuses, cannulation and lavage are not recommended. In frontal sinusitis, there is a place for external trephination but instrumentation of the frontonasal duct is best avoided as it commonly produces stenosis. Concomitant involvement of the antrum often compounds these situations and must be treated at the same time.

The intranasal and transantral approaches to the ethmoids combine an inability to perform total exenteration of the cells with significant potential hazard and require considerable surgical expertise. As fewer of these operations are performed, this expertise is increasingly difficult to obtain. In 1969, Davison reported on 100 consecutive cases and
attributed his improved results to his greater familiarity with the anatomy, a view which has been supported by Freedman and Kern (1979). In opening the ethmoids sufficiently to relieve obstruction, and allowing drainage and ventilation, it may not be necessary to remove every vestige of diseased mucosa and exenterate every cell. In aiming merely to decrease the incidence of recurrence rather than eliminate it, these operations have a role especially in polypoid disease of the antroethmoidal complex. It is, therefore, important to preserve the middle turbinates as a future landmark in these circumstances. However, there are many surgeons today who would agree with Mosher’s remark (1929) that ‘intrasanal ethmoidectomy is the blindest and most dangerous in all surgery’.

The external frontoethmoidectomy offers excellent access and minimal postoperative complications. Although it also requires a thorough understanding of the anatomy, it is the treatment of choice in any established condition. The success of the procedure is dependent upon adequate removal of the frontal sinus floor, removal of the entire mucosal lining, complete exenteration of the ethmoid cells and opening into the sphenoid, and the establishment of a large permanent drainage channel into the nasal cavity.

The need for radical frontal sinus surgery is decreasing and while the osteoplastic flap still has a role for the most intrasigent disease, it is rarely implemented and offers few advantages over a radical external frontoethmoidectomy.

**Sinusitis in children**

Because of the development of the sinuses, sinusitis is unlikely to be a clinical problem before 2-3 years of age. Acute infections, particularly of the ethmoids, may result from any upper respiratory tract infection, chronic sinusitis may accompany recurrent adenotonsillitis. Cleft palate deformities, choanal atresia, foreign bodies, tumours and allergy may all predispose to infection, although the teeth are rarely a source of problems, as the deciduous teeth are separated by the buds of the permanent dentition.

Interpretation of X-rays can be difficult due to the size of the sinuses and symptoms of nasal obstruction, mucopurulent discharge and cough may not be directly related to sinusitis. However, antral puncture may be indicated after failure of medical treatment, usually in conjunction with adenoidectomy and tonsillectomy and always under general anaesthesia.

Cannulation and daily washouts are not tolerated well by young children and it is occasionally necessary to resort to an inferior meatal antrostomy. Anatomical restrictions and continuing bone growth result in early closure of the holes. Care must be exercised to avoid damage to the teeth roots and for this reason the Caldwell-Luc operation is not recommended. While decompression of orbital cellulitis resulting from acute ethmoiditis is sometimes necessary, surgical intervention in the frontoethmoidal region is rarely indicated.