Functional endoscopic sinus surgery

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Basic principles of when and how to apply FESS.

The anatomy of the nose, paranasal sinuses and surrounding regions is complex with many variations (Figs 1-4). The middle meatus is the final common pathway of the maxillary and anterior ethmoidal sinuses as well as the latter's developmental extension, the frontal sinus, if present. The anterior recess of the superior meatus receives the posterior ethmoidal system. The ostia of the sphenoid sinuses drain into the sphenoethmoidal recesses, on either side of the posterior septum.

The functions of the nasal mucosa and its mucociliary clearance mechanism are well known (Table I). However, the function of the sinuses is unknown. Over a period of time systemic and upper respiratory disease processes, either chronic or acutely recurrent, alter the normal patterns (Figs 2, 5) of mucociliary clearance of the sinuses. These specific clearance patterns are unaffected by secondary, often iatrogenic (eg, inferior meatal antrostomy) drainage or ventilation sites. Mucosal swelling not only alters the ciliary clearance pattern of the mucosal blanket via the natural sinus ostia, the transition zones and the meatal clefts, but also adversely affects the ventilation status of each cavity ('sinus'). More specifically, mucosal contact pathology in the ostiomeatal unit (OMU), the frontal recess or the sphenoethmoidal recess is most often the indication for primary or revision surgery (Figs 5, 6).

Table I. **Function of the nose/mucosal lining**

Ventilation: A passage to facilitate ventilation.

Respiration (inspiratory air): Humidification. Warming. Filtering or neutralisation of noxious particles.

Olfactory: Perceiving odours, pleasant or obnoxious.

Reflexes: Regulating breathing and heart rate.

Aesthetic: Familial or ethnic characteristics.

Normal sinunasal anatomical variations (Fig. 6, Table II) may, usually in combination with nasal inflammatory conditions of insidious onset, lead to a chronic rhinosinusitis refractory to appropriate conservative management.

In summary, the physiological basis of any form of management largely is that the OMU is the central area of mucociliary clearance of the anterior sinunasal unit and impairment mainly in this area leads to ongoing sinusitis. Eradication of OMU disease improves the ventilation and drainage of the inflamed sinuses, allows the resumption of mucociliary clearance and creates a turn-about in the vicious cycle of progressive mucosal pathology.

Table II. **Sinunasal anatomical variants (may be single or in combination)**

Nasal cavity: Narrow - very medial origin of inferior turbinate; choanal stenosis. Fovea ethmoidalis: weak, low.

Lateral nasal wall: Fontanelle; dehiscent lamina papyracea.

Septum: Deviation, ridges; spurs; broadness; duplication; perforated.

Middle turbinate: Duplicated; bulbous; aerated (concha bullosa - 13%); paradoxically curved (17%); long (in AP and/or vertical extent); lateralisation.

Inferior turbinate: Large; horizontal origin.

Uncinate process: Medialised; lateralised (intimacy with BE: 'hand-on-ball'); aerated.

Anterior ethmoid: Large bulla ethmoidalis (BE) (20%); enlarged agger nasi cells (3%); supraorbital ethmoid; Haller cells (2%).

Posterior ethmoid: Onodi cell; relationships with sphenoid sinus.

Frontal sinus: Absent; tri-partite; intrasinus bulla; indifferent drainage pathways.

Sphenoid sinus: Septation; size; double ostia.

Lamina papyracea: Dehiscence.

Single or recurrent sinus lavage procedures are temporary 'non-functional' measures to remove inspissated fluid from a sinus and are mostly used in pathology of less than 6 weeks' duration where local and systemic decongestive therapy failed.

Functional endoscopic sinus surgery (FESS) refined the surgical experience and includes minimally invasive techniques. It must be seen as an additional option to aggressive continual medical management of the diseased residual sinunasal mucosa. FESS is often combined with nasal cavity surgery, including functional septal and turbinate techniques; however some applications do not necessitate an endoscope.

Essentials (Table III)

➤ An understanding that we often deal with multifactorial disease.

➤ A thorough clinical assessment, integrating a preoperative well-directed medical treatment schedule (allergy, bacteriology, etc) with the final endoscopic and CT findings, creates a 3-dimensional mental picture of the patient's normal and affected anatomy.

➤ Avoid surgery in the acutely infected state.

➤ A sound knowledge how to combine tools and technique to:

➤ gain operative access to disease

➤ avoid potential harmful complications

➤ create minimal iatrogenic mucosal trauma

➤ apply intra- as well as post-operative treatment measures to prepare for adequate postoperative access and care to the diseased and now iatrogenically disturbed mucosal site(s) (eg, establishing a stable non-lateralising and non-obstructive middle turbinate; managing inferior turbinate hypertrophy).

➤ A staging system (Table IV and CT scans) to determine the extent of FESS necessary for varying degrees of sinusitis. Surgeons often apply by experience the different available options (single or in combination) to the specific problem. This system emphasises the variation in and complexity of sinus involvement; often in need of aggressive, but cautious peri- and intraoperative management.

➤ The paediatric patient often has a different pathophysiology where other contributions are more often seen, eg, GORD and congenital mucociliary defects. The older child (6 and above) may however demand an 'adult approach', except that their more limited sinunasal passages often create technical difficulties. Therefore if in doubt:

➤ a more protracted and aggressive conservative treatment schedule is applied, either to cure or as operative preparation

➤ consider, in combination with FESS, repeated postoperative maxillary sinus saline lavages via an indwelling tube to 'wash' and clear the ostiomeatal complex (OMC) (± 3 days)

➤ consider a return to theatre 1 week postoperatively for a routine endoscopic nasal toilet and sinus lavage

➤ consider a relook under general anaesthesia after 3 months.

➤ Exercise patience. Convey to the patient or the family the essential thought processes relating to the individual's own pathophysiology and important operative aspects (morbidity, expectations and possible secondary procedures). Explain all grey areas and limitations and most importantly the necessity for postoperative availability for care.

Table III. **Summary: preoperative assessment and management**

➤ Systematic endoscopic examination (topical decongestion with 0.25% neo-synephrine or 5% cocaine; 0° or 30° 4 mm endoscopes; + 2.7 mm 0° endoscope): including the nasopharynx

➤ Radiological assessment: CT after best clinical response to medical Rx, identifying the primary pathology (avoiding an image of secondary mucosal changes), the extent of disease and to anticipate anatomical variations. Concepts: the 'road map' in theatre; coronal ± axial planes; 'full' or 'limited' scanning

➤ Other

- ➤ Drug schedule (achieve a possible quiescent stage; steroids where appropriate)
- ➤ Asthmatics; aspirin sensitivity
- ➤ Exclude a bleeding disorder/potential bleeding disorder (drug-induced)
- ➤ Information sheet.

FESS: Indications

➤ Acute recurrent sinusitis: 4 adequately treated events per year.

➤ Chronic hyperplastic rhinosinusitis: adequately treated and present for longer than 3 months, including nasal polyps and mucocoele formation.

➤ Nose- and sinus-related (so-called 'sinus') headaches, including middle turbinate and septal contact effects - often without significant mucosal hyperplasia in the allergic rhinitis sufferer.

➤ A double maxillary or sphenoidal 'ostium' (mucus recirculation causes a continuous, often clear postnasal discharge).

➤ Orbital complications (cellulitis; abscess).

➤ Other: fungal (diabetics, immunocompromised states), neoplasms (removal, debulking, biopsies).

The Procedure

Anaesthesia

In RSA the procedure is generally done under general anaesthesia; smaller or minor secondary procedures are done under local anaesthesia.

Surgical technique

As per Table IV; functional nasal surgery (FNS) will not be discussed here.

➤ Patient position supine, 15° reverse Trendelenburg. Radiology screen and/or endoscopic monitor easily visible.

➤ Local infiltration (1% xylocaine with 1:100.000 adrenaline): varied. The microdebrider allows one to avoid infiltration, except for a partial middle turbinectomy/septal surgery. Different areas in the region of the uncinate process (UP) and the middle turbinate (MT) are often targeted.

The following is a general surgical sequence. Applications are kept to the minimum to conserve mucosal lining, thereby generally avoiding bleeding, adhesions and the formation of osteitic bone:

➤ *Gaining access to the OMC* (Fig. 7): septoplasty, conservative submucosal inferior or middle turbinate procedures, including a possible lateral fracture of the inferior turbinate.

➤ *Maxillary sinus ostial exposure:* uncinectomy (partial or complete).

➤ *Maxillary sinus antrostomy* (ostial enlargement if inadequate ± incorporating another maxillary sinus window; ± reduction of Haller cells): avoid removal of hyperplastic mucosa, but obstructing pathology should be removed (polyps; large mucus retention cysts).

➤ *Ethmoidectomy*

➤ The ethmoid bulla is exenterated, penetrated at its most inferomedial aspect, but taking care to extend this into its more posterior situated ostium.

➤ The anterior ethmoidectomy is completed by 'removing' the agger nasi cells, taking care to expose the frontal sinus ostium as atraumatically as possible. Also avoid circumferential trauma to the exits of supraorbital cells if present.

➤ Penetrating the ground lamella allows access to the posterior ethmoidal cells. Ensure patency of the superior meati.

➤ *Sphenoidotomy:* the trans-sphenoethmoidal recess approach is preferred.

➤ Frontal sinus techniques: fewer surgeons in the USA and Europe now use the external approach. A minor external trephine with an indwelling 3-mm irrigation tube may assist in postoperative care when an internal drill-out procedure is performed. The aim is to create a combined frontal sinus internal ostium. It eliminates the morbidity associated with the external approach.

➤ *Placement of silastic* (or other: Gelfilm; Merocel; Allevyn) *stents* in the meati to prevent stenosis or adhesions. Stabilisation techniques aimed at the middle turbinate are to prevent lateralisation. Improved technique and instrumentation now limits the necessity of many of these precautionary measures.

➤ Managing complications.

Postoperative Management

Weekly follow-up for at least 2 weeks. Meticulous endoscopic care including local debridement, nasal douching to clear most dried blood and crusts (buffered saline solution), division of synechiae and medical care tailored to the pathology. Removal of splints: duration of their stay varies.

Complications

As in all postoperative situations the complications of FESS may be immediate or delayed. The immediate group is discussed here.

Epistaxis

This is the most common complication, and it is usually caused by direct vessel trauma or a systemic coagulation problem. Nasal packing and electrocautery are usually effective. A potentially lethal but rare scenario may be a carotid artery injury during a sphenoidectomy or posterior ethmoidectomy.

Injuries lateral to the lamina papyracea

- ➤ Subcutaneous emphysema: medial canthal swelling (innocent, recovers within 7 days)
- ➤ Orbital cellulitis
- ➤ Orbital abscess
- ➤ Medial rectus and superior oblique injury - entrapment injuries are serious
- ➤ Optic nerve injury
- ➤ Orbital haemorrhage (a tense proptotic globe warrants an emergent lateral canthotomy ± transection of the lateral canthal ligament. Add dexamethasone 0.5 mg/kg and mannitol 1.0 mg/kg).

The surgeon should be aware of the signs of bony dehiscence, including orbital fat at all times. In such circumstances an antibiotic is compulsory and the patient must abstain from blowing the nose while exerting alar pressure until instructed by the surgeon. Postoperatively the eye should be examined carefully.

Cerebrospinal fluid leak

This is usually caused by dural dehiscence and penetration. This may result from a cribriform plate fracture during improper management of the middle turbinate or from a direct injury to the fovea ethmoidalis. A direct injury usually occurs at the posterior aspect of the frontal recess or at the spheno-ethmoidal recess. The patient should be informed of this rare possibility preoperatively and be made aware of the danger symptoms and signs, especially to avoid a delayed diagnosis which may present as a septic meningitis as a worst event.

Nasolacrimal duct injuries

Avoid biting backward doing the antrostomy. A dacrocystorhinostomy endoscopically performed is usually successful.

Expectations and Causes of Ongoing Rhinosinusitis

In principle the nose will not be healthy on day 1. The surgeon's aim is to create reversible disease: the more severe the preoperative mucosal pathology, the longer it will take for remission to occur. The following is therefore of importance:

- ➤ the multifactorial nature of the preoperative aetiology
- ➤ inadequate surgery as well as 'non-reachable' persistent lateral frontal sinusitis and supraorbital ethmoid sinus disease
- ➤ nasal crusting
- ➤ refractory osteitis
- ➤ overzealous removal of nasal crusting, a chronic rhinitis (even atrophic changes) and late-onset bronchitis.

Current Advances in Technology

The endoscope, thru-cutting instrumentation, shaving (Fig. 8) and LASER systems, 3-D computer-directed surgery now allows more complete exenteration of disease with added safety.

In a Nutshell

The sinunasal unit includes a complexity of sinus cells, all of which communicate with the nasal cavity via specialised ostia and pathways (prechamber systems).

Diseases processes, more often in the ostiomeatal unit (OMU), may be of a multifactorial origin.

These disease processes, more often of rhinogenic origin, disturb the clearance patterns of the mucociliary blanket.

The standard of functional care now includes thorough endoscopy and computed tomography (CT).

This, in combination with conservative treatment measures, will prepare irreversible sinunasal disease for functional nasal and endoscopic sinus surgery (FNS and FESS).

Many surgical applications exist: they should be tailored to the extent of the disease and aim to conserve mucosa.

The frontal sinuses are the most difficult to manage.

The sinunasal lining needs extensive postoperative care to prevent complications and secondary surgery.

Fig 1. Normal left ostiomeatal unit (OMU) - coronal dissection. (FS = frontal sinus; BE = bulla ethmoidalis; IT = inferior turbinate; MA = maxillary antrum).

Fig 2. Normal drainage patterns of the maxillary (a) and frontal sinuses (b).

Fig 3a. Sagittal section through the left middle turbinate, noting the structures of the lateral wall of the nasal cavity.

Fig 3b. Sagittal section through the right nasal cavity showing the hiatus semilunaris (BE = bulla ethmoidalis; IT = inferior turbinate; UP = uncinate process).

Fig 4. Coronal CT of the normal nasal cavity at the level of the OMU (compare this to Fig 1).

Fig 5. Pathophysiology and management of rhinosinusitis.

Fig 6a, b. Contributions to pathology by a number of anatomical variations.