An Overview of Computed Tomography Role in assessment of Sinonasal Polyposis

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Abstract

Background: Sinonasal polyps history goes back over 4000 years to ancient Egypt. Broadly defined, nasal polyps are benign semitransparent nasal lesions that arise from the mucosa of the nasal cavity or from one or more of the paranasal sinuses, often at the outflow tract of the sinuses. The etiology of nasal polyposis is mainly unknown, although it has been connected with many causes like allergy, infections (bacterial and fungal), diseases associated to nasal polyps like Samter’s triad, environmental pollutants, and local host factors like deviated septum. CT has become the investigation of choice for radiological diagnosis of nasal and sinus diseases as CT images clearly show air spaces, opacified sinuses and fine structural architecture of bony anatomy. MSCT can show anatomic structures that are not visualized by physical examination or diagnostic nasal endoscopy and is, hence, the study of choice for the surgeon who is considering functional endoscopic sinus surgery. Functional endoscopic sinus surgery (FESS) has considered as an effective treatment option and also is the treatment of choice for medically refractory chronic rhino sinusitis (CRS) with and without sinonasal polyposis with excellent success rates. Technical developments in computer-assisted tomography such as multidetector CT (MDCT) technique can help the surgeon and increase the diagnostic accuracy.

Keywords: Sinonasal Polyposis, Functional Endoscopic Sinus Surgery (FESS).

Background

Chronic rhinosinusitis (CRS) is one of the most frequent chronic diseases worldwide and a little is understood about its pathogenesis (1).

CRS most likely consists of different phenotypes. The different phenotypes of CRS are often lumped together as a single disease entity, because at this moment it seems impossible to clearly differentiate between them (2).

CRS with nasal polyps (NP) is one of the subgroups that have the most distinctive characteristics. NP is a recurrent affection of nasal mucosa characterized by chronic inflammatory processes but its etiology and pathogenesis remain unclear. NP consist of loose connective tissue, edema, some gland and capillaries and inflammatory cell infiltration comprising eosinophils, neutrophils, mast cells as well as lymphocytes with increased proportion of T cells. It causes considerable morbidity like nasal obstruction, rhinorrhoea, and anosmia (3).
Several pathogenetic theories on the formation of nasal polyps have been published during the last 150 years, but complete understanding of the pathophysiology of rhinosinusitis remains elusive, inspite of several infectious and inflammatory pathways have been identified (4).

**Computed Tomography (CT) in sinonasal polyposis**
It is possible to study the intricate anatomy of paranasal sinuses by computed tomography (CT) and, more importantly, their relation to the surrounding vital structures such as skull base, lamina papyracea, internal carotid artery and optic nerve. It delineates key areas such as infundibulum and ostiomeatal complex. CT scanning is now mandatory in the pre-operative evaluation of sinus disease before undertaking functional endoscopic sinus surgery (FESS) (5). CT of the nose and paranasal sinuses is the ideal imaging exam (gold standard) to study nasal and paranasal sinuses diseases and is now considered as the study of choice for chronic rhino sinusitis, since it simulates the endoscopist’s view of the sinonasal cavity and provides a bony road map for surgery, with early monitoring for recurrence (6). Among sinus surgeons, endoscopy is considered the primary means of evaluating sinonasal cavity. However, radiology may provide a more complete analysis of the nasal cavity and sinuses. This is particularly true when the nasal cavity is completely filled with tissue, as may be the case in NP (7).

**Intravenous contrast material**
The use of intravenous contrast material e.g Omnipaque just prior to scanning can help define soft tissue lesions and delineate vascularized structures, such as vascular tumors. Contrast-enhanced CT (CECT) is particularly useful in evaluating neoplastic, chronic, and inflammatory processes as in cases of acute sinusitis complicated by periorbital cellulitis or abscess. However, for most patients with sinusitis and sinonasal polyps, non-contrast CT of the paranasal sinuses generally suffices (8).

**The Timing of CT Scanning**
The timing of CT scanning can have a significant impact on the correlation of CT findings with actual disease state. As such, CT scans should be obtained only after acute sinusitis episodes have been adequately treated. Changes from acute infections to baseline state can last several weeks so, waiting for at least 6 weeks before obtaining a scan is recommended to determine the patient's baseline disease status. Patients with chronic inflammatory disease, such as strong allergies and/or sinonasal polyposis disease, should receive maximized medical therapy for a few weeks before undergoing CT scanning (9).

**Degree of confidence: False positives/negatives**
CT findings should not be interpreted in isolation, and scans should always be read in conjunction with clinical and endoscopic findings because of high rates of false-positive results. Up to 40% of asymptomatic adults have abnormalities on sinus CT scans, as do more than 80% of those with minor upper respiratory tract infections (10).
CT signs of sinonasal polyposis
Polyps appear radiographically as rounded nodules of soft tissue along the mucosal surfaces of the paranasal sinuses and nasal cavity. They are usually more radio dense than the surrounding mucosal thickening or secretions, which make them appear slightly brighter on Non contrast enhanced CT (NCECT). This pattern may be reversed if the secretions become inspissated. Sometimes, a thin pedicle is visible connecting the bulk of the polyp to the mucosal surface. This sign may be helpful when it is present, but it is not seen in the majority of polyps. Polyps do not erode into the surrounding bone, but pressure from a polyp may produce a benign local remodeling pattern that scallops the underlying bone. This is distinct from a mucocele, in which the entire sinus expands. This bone remodeling will occasionally see as thin bony septations beyond the resolution of CT, giving the appearance of bone erosion, particularly in the ethmoid septations. Polyps themselves do not enhance with contrast administration. However, the mucosa surrounding the polyp may enhance, giving the impression of rim enhancement. This thin, uniform rim of enhancement is usually distinguishable from the complete enhancement of non-necrotic tumors and the irregular enhancement of necrotic tumors (11).

Fig.1: Hyperdense sinonasal polyps. Axial CT shows polyps (arrows) within the maxillary sinus. The polyps are denser than the surrounding secretions (12).

Fig.2: Hyperdense secretions. Axial CT shows innumerable polyps in the maxillary sinus in a patient with NP (Nasal polyposis). (12).
Fig.3: Bony remodeling from polyps. Coronal CT shows lobular remodeling of the maxillary sinus walls (arrow heads) in this patient with NP. This scalloped pattern suggests a benign etiology (12).

Fig.4: Remodeling of the ethmoid septa. Axial CT of a patient with NP shows thinning of the posterior ethmoid septa (arrow) so that they are no longer visible on CT. This is still a benign (12).

**CT-based Staging systems for chronic rhinosinusitis (CRS)**

Numerous CT-based staging formulas for sinus disease have been proposed, each with advantages and disadvantages (13).

The better-known CT staging systems are reviewed in this section as follows,

**1-Kennedy staging system**

The Kennedy system, proposed in (14), is designed to evaluate factors predictive of outcome in chronic inflammatory sinus disease. The data provided a basis for a rational staging system used in the stratification of patients with more accurate evaluation of the results of different treatment modalities. The system consists of four patient categories and stages based on severity of the disease:

**The Stage I**: anatomic defects, all unilateral sinus disorders and bilateral disorder of the ethmoid sinuses.

**The Stage II**: bilateral ethmoid sinus disorder, with involvement of one dependent sinus
The Stage III: bilateral ethmoid sinus problems with involvement of two or more dependent sinuses on each side
The Stage IV: represents diffuse sinonasal polyposis (14).

2-Levine and May staging system
The Levine and May staging system, proposed in (23), considers the involvement of the ostiomeatal channels but seems to make no distinction between the involvement of a single sinus or all the sinuses (13).

3-Lund-Mackay staging system
Perhaps the mostly widely accepted CT scan classification system in chronic rhino sinusitis is the Lund-Mackay system, proposed in 1993. To address the objective of reproducibility, the system is deliberately reduced to a simplistic form that minimizes individual variation in the interpretation of the degrees of opacification. It requires no formal radiologic training, only the ability to identify the major sinuses and to distinguish between null, partial, or total sinus opacification (15).

Table 1: Lund- Mackay scoring system.

<table>
<thead>
<tr>
<th>Sinus</th>
<th>Left</th>
<th>Right</th>
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</thead>
<tbody>
<tr>
<td>Maxillary (0,1,2)</td>
<td>(0,1,2)</td>
<td>(0,1,2)</td>
</tr>
<tr>
<td>Anterior ethmoid (0,1,2)</td>
<td>(0,1,2)</td>
<td>(0,1,2)</td>
</tr>
<tr>
<td>Posterior ethmoid (0,1,2)</td>
<td>(0,1,2)</td>
<td>(0,1,2)</td>
</tr>
<tr>
<td>Sphenoid (0,1,2)</td>
<td>(0,1,2)</td>
<td>(0,1,2)</td>
</tr>
<tr>
<td>Frontal (0,1,2)</td>
<td>(0,1,2)</td>
<td>(0,1,2)</td>
</tr>
<tr>
<td>Osteomeatal complex (0 or 2)</td>
<td>(0 or 2)</td>
<td>(0 or 2)</td>
</tr>
<tr>
<td>Total (0-24)</td>
<td>(0-12)</td>
<td>(0-12)</td>
</tr>
</tbody>
</table>

4-Harvard staging system
The Harvard staging system, proposed in 1994, is similar to Kennedy’s system, but takes into consideration the thickening of inflammatory disease. This staging makes no distinction between patients without evidence of mucosal inflammation and those having inflammatory mucosal thickening of less than 2 mm (16).

Table 2: Harvard staging system

<table>
<thead>
<tr>
<th>Staging</th>
<th>Features</th>
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<tbody>
<tr>
<td>0</td>
<td>Normal (&lt;2 cm mucosal thickening on any sinus wall)</td>
</tr>
<tr>
<td>I</td>
<td>All unilateral disease or anatomical abnormality</td>
</tr>
<tr>
<td>II</td>
<td>Bilateral disease limited to ethmoidal or maxillary sinuses</td>
</tr>
<tr>
<td>III</td>
<td>Bilateral disease with involvement of at least one sphenoid or frontal sinus</td>
</tr>
<tr>
<td>IV</td>
<td>Pansinusitis</td>
</tr>
</tbody>
</table>
**Challenges in CT based staging system for CRS**

Although results from the Lund-Mackay system are accurately reproducible, there are still clinical challenges that are not addressed by this method of classification. This and other current classification systems lack sufficient levels of gradation for tracking progression or reduction of the disease volume with adequate precision (17).

The correlation between patient symptoms in CRS with polyps and CT findings is difficult to determine partly because chronic mucosal inflammation may be present without CT findings and asymptomatic persons can have abnormal CT scans. Several studies failed to show a correlation between symptom severity and severity of CT findings. In particular, symptoms such as headache and facial pain do not correlate with CT findings at all (18).

**Functional endoscopic sinus surgery (FESS)**

Functional endoscopic sinus surgery (FESS) is a minimally invasive surgical treatment which uses nasal endoscopes to enlarge the nasal drainage pathways of the paranasal sinuses to improve sinus ventilation (19).

This procedure is generally used to treat inflammatory and infectious sinus diseases, including chronic rhinosinusitis that doesn't respond to drugs, nasal polyps, some cancers, and decompression of eye sockets/optic nerve in Graves ophthalmopathy (20).

In the surgery, an otolaryngologist removes the uncinate process of the ethmoid bone, while visualizing the nasal passage using a fiberoptic endoscope (19).

FESS can be performed under local anesthesia as an outpatient procedure. Generally, patients experience only minimal discomfort during and after surgery. The procedure can take from 2 to 4 hours to complete (21).

**Medical applications**

![Figure 5](image.png)

**Figure 5** Large nasal polyp (round mass, center), which is commonly treated and removed by FESS (20). Functional Endoscopic Sinus Surgery is most commonly used to treat chronic rhinosinusitis (20), only after all non-surgical treatment options such as antibiotics, topical nasal corticosteroids, and nasal lavage.
with saline solutions have been exhausted. Chronic rhinosinusitis (CRS) is an inflammatory condition in which the nose and at least one sinus become swollen and interfere with mucus drainage (20).

It can be caused by anatomical factors such as a deviated septum or nasal polyps (growths), as well as infection. Symptoms include difficulty breathing through the nose, swelling and pain around the nose and eyes, postnasal drainage down the throat, and difficulty sleeping. CRS is a common condition in pediatric patients and young adults (22).

The purpose of FESS in treatment of CRS is to remove any anatomical obstructions that prevent proper mucosal drainage. A standard FESS includes removal of the uncinate process, and opening of the anterior ethmoid air cells and Haller cells as well as the maxillary ostium, if necessary (23). If any nasal polyps obstructing ventilation or drainage are present, they are also removed. In the case of paranasal sinus/nasal cavity tumors (benign or cancerous), an otolaryngologist can perform FESS to remove the growths, sometimes with the help of a neurosurgeon, depending on the extent of the tumor and in some cases, a graft of bone or skin is placed by FESS to repair damages by the tumor (24).

In the thyroid disorder known as Graves Ophthalmopathy, inflammation and fat accumulation in the orbitonasal region cause severe proptosis (25). In cases that have not responded to corticosteroid treatment, FESS can be used to decompress the orbital region by removing the ethmoid air cells and lamina papyracea. Bones of the orbital cavity or portions of the orbital floor may also be removed (19).

FESS is a less invasive method than open sinus surgery, which allows patients to be more comfortable during and after the procedure. Entering the surgical field via the nose, rather than through an incision in the mouth as in the previous Caldwell-Luc method, decreases risk of damaging nerves which enervate the teeth. Because of its less-invasive nature, FESS is a common option for children with CRS or other sinonasal complications (26).

**Outcomes and complications**

Functional Endoscopic Sinus Surgery is considered a successful if most of the symptoms, including nasal obstruction, sleep quality, olfaction and facial pain, are resolved after a 1–2-month postoperative healing period (27).

Reviews of FESS as a method for treating chronic rhinosinusitis have shown that a majority of patients report improved quality of life after undergoing surgery (22).

The success rate of FESS in treating adults with CRS has been reported as 80-90%.[18] and the success rate in treating children with CRS has been reported as 86-97% (28).

The most common complication of FESS is cerebrospinal fluid leak (CSFL), which has been observed in about 0.2% of patients. Generally, CSFL arises during surgery and can be repaired with no additional related complications postoperatively. Other risks of surgery include infection, bleeding, double vision usually lasting a few hours, numbness of the front teeth, orbital hematoma, decreased sense of smell, and blindness (19).

Blindness is the single most serious complication of FESS, and results from damage to the optic nerve during surgery. Serious complications such as blindness occur in only 0.44% of cases, as determined by a study performed in the United Kingdom (29).
References.


