ABSTRACT

Nowadays, the introduction of microsurgical techniques, the development of minimally invasive surgical techniques, and functional rhinosinus surgery have defined a qualitatively new approach to the treatment of rhinosinusitis. This article describes the approaches and methods of functional endoscopic sinonasal surgery (FESS) for the treatment of fungal rhinosinusitis. The basic principles of FESS for fungal sinus infections are presented and surgical schemes for various variants of localization of fungal bodies in the sinuses are given.

Keywords: paranasal sinuses (PNS); mycotic infection; fungal rhinosinusitis; surgical treatment; functional endoscopic sinonasal surgery.

INTRODUCTION

In recent years, there has been a trend towards a significant increase in the incidence of sinusitis and an increase in chronic forms caused by atypical pathogens, saprophytic flora that under conditions of healthy biocenosis of the mucous membranes, usually does not lead to inflammation. Fungal infections have recently gained prominence in the etiology of rhinosinusitis (RS) [1,2,3]. An increase in immunodeficiency conditions, unfavourable environmental conditions, inappropriate use of antibiotics, immunosuppressive therapy and other causes underlie the diseases collectively termed "fungal sinusitis". Despite the introduction of new medications, the problem of fungal rhinosinusitis remains relevant to modern otorhinolaryngology. Progress in mycology, serology, histopathology, and radiology has improved the diagnosis of fungal lesions of the nasal cavity and paranasal sinuses (PNS). However, clinical studies in our country and abroad have shown a real increase in the incidence of sinusitis of fungal etiology [4,5,6].

The accumulated world experience, further improvement of methods of diagnosis of fungal infections of PNS using clinical, endoscopic, microbiological, morphological, immunological,
radiological studies allow us to study the epidemiology of the disease, determine the features of the course, preventive measures, qualitatively improve methods of therapeutic and surgical treatment of different clinical forms of fungal sinusitis [7,8].

The introduction of microsurgical techniques, the development of minimally invasive surgical techniques, and functional rhinosinus surgery have defined a qualitatively new approach to the treatment of rhinosinusitis.

Endoscopic PNS surgery (FESS) is based on the concept of W. Messerklinger, according to which the pathogenesis of chronic RS is based on a disruption in the ventilation of the PNS caused by anomalies and local pathology in the ostiomeatal complex. Surgical intervention in the "key" area, removal of pathological tissues blocking the PNS orifices, and restoration and aeration contribute to the elimination of the inflammatory process. If the extent of the pathological process does not allow the necessary amount of surgery to be performed by intranasal endoscopy alone, it can be supplemented by gentle external access [9,10].

![Figure 1. Osteomeatal complex](image)

The concept of functional endoscopic surgery of the PNS is further developed by the new, balloon osteoplasty technique. This method, designed to treat chronic MS, can be used according to specific indications when the prevalence of inflammation is limited to one or two PNS and the primary cause is the obstruction or dynamic dysfunction of their natural orifices (Fig. 1). In these cases, non-invasive dilation of the affected sinus's annexation using an inflatable balloon, which
is inserted on a guide wire under endoscopic control, is sufficient to restore normal sinus ventilation and eliminate the inflammatory process [11,12].

The main aim of FESS is to preserve the anatomical structures of the nasal cavity and the PNS as much as possible. FESS stipulates:

- removal of polyposis tissue using a shaver, preserving the middle and inferior turbinate;
- correction of deviations of the nasal septum;
- opening of the osteomeatal complex, thoroughly opening the ethmoid sinuses.

In addition, FESS provides access to the sinus and thereby restores ventilation and drainage through the natural accessory sinuses of the PNS. Please note: surgical treatment of chronic rhinosinusitis (CRS) should only be performed after maximal drug therapy.

The efficacy of primary surgery for CRS is quite high and obviously depends on the level of training of the surgeon and the level of equipment in the medical institution. In particularly difficult cases, surgical navigation is used.

The concept of FESS suggests reversibility of pathological structural changes in the mucosa, although this often contradicts the results of surgical treatment. Few histological studies show that, despite the clinical improvement, electron microscopy demonstrates irreversible mucosal changes after surgery. This is why some surgeons advocate radical surgical techniques.

The main purpose of surgical intervention is to restore aeration and drainage of the paranasal sinuses and to ensure drug delivery to the PNS mucosa [13,14,15].

Studies have shown that, compared with radical surgery, FESS reduces symptoms and improves the quality of life in patients with CRS. Surgical treatment is unsuccessful due to the recurrence of inflammation and polyposis, the formation of synechiae, lateralisation of the middle nasal concha, and postoperative stenosis of the PNS junction [16,17]. This is why it is advisable to use mometasone furoate quite early in the postoperative period. Controlling these factors can improve surgical outcomes.

**Endonasal techniques and post-operative management of fungal rhinosinusitis.**

Fungal glomeruli most commonly occur in the maxillary sinus, although they can also be found in the sphenoid and less frequently in other sinuses.

Complete removal of the fungal mass leads to resolution, although bacterial sinusitis is also often present, requiring treatment with antibiotics. Removal of fungal conglomerates from the maxillary sinus can usually be performed using curved suction through a wide median antrostomy. If the mass cannot be adequately removed in this way, the trocar can be inserted and used as a spoon during endoscopic imaging to scoop out the mass towards the antrostoma. The
cavity should be examined with a telescope at 70˚ to ensure that the mass is properly removed. Subsequent revision of the cavity in the postoperative period is done with a curved telescope to ensure complete removal of the remaining fungal particles [8].

Fungal rhinosinusitis may be associated with a marked degree of bone remodelling. This is particularly important from a surgical point of view, as the anatomical relationships can change dramatically. The development of bone erosion, with the displacement of the optic nerve and carotid artery, is not uncommon when the sphenoid or ethmoid sinus is involved in the pathological process [6,9].

The aim of surgery for allergic fungal rhinosinusitis is the complete removal of all thickened tissue and mucosal polyps, and the complete removal of the inter-sinus septum with a wide antrostomy of the middle nasal passage. However, in all surgical interventions involving inflammatory PNS illnesses, care must be taken to preserve the mucosal-periosteal coverage of the bone within the cavity. Steroid therapy in the early preoperative period helps to reduce polyps and, more importantly, to reduce intraoperative bleeding.

In the postoperative phase, all patients require both topical and systemic glucocorticosteroids. Antibiotics (to minimize the concomitant bacterial component of sinusitis), fungal desensitization, antifungal irrigation, and oral antifungal medications can all be beneficial postoperative adjuvant treatments [19].

Chronic invasive fungal sinusitis usually requires both a conservative radical open approach and a full course of antifungal therapy. Surgery, in this case, must include removal of all soft tissue and bone involved that can be safely removed, but also care must be taken to avoid resection or disruption of the dura mater and orbital periosteum. Both structures are relatively strong barriers to fungal infection, and ruptures in these structures can facilitate the migration of fungus beyond their borders. In the development of granulomatous invasive disease, endoscopic access may be useful in draining the cavity when the affected area cannot be completely excised. Endoscopic access with biopsy is very useful in the diagnosis of fulminant forms of fungal rhinosinusitis. Although there are occasional reports in the literature about the use of endoscopic access, with positive results, wide single-block resection with intravenous antifungal agents and correction of immunodeficiency remains the "gold standard" of the therapy [3,4,7,12].

Removal of the entire uncinate process of ethmoid is not necessary, but a wide opening of the sinus in the middle nasal passage and a downward extension of the superimposed opening is required. The size of the applied anus must be sufficient for a good view of the anterior and inferior walls when viewed at 30° and 70° with an endoscope. The fungal body is removed with suction tips or curettes that are bent at different angles. The altered mucosa is removed using Binner's double spoon forceps with an 80° angle. We never use an additional trocar puncture through the
anterior wall, as we do not believe it offers any additional benefits, but only increases the traumatic nature of the intervention, the likelihood of fungus implantation in the cheek tissue, and the development of postoperative trigeminal neuralgia [11,15,18].

As this form is a non-invasive fungal disease, systemic administration of antifungal drugs in the postoperative period does not make sense. A thorough cleaning of the nasal cavity and open cavities and several flushes of the operated sinus with a quinazoline or other antifungal solution is sufficient. Most authors report that after surgery and restoration of normal drainage and aeration of the sinus, the cure rate of this form of fungal sinusitis approaches 100%. Our observations support this statement [6,8,10].

The treatment of allergic fungal sinusitis must begin with endonasal surgery. The extent of this intervention may vary depending on the extent of the disease, however, it is imperative to remove as much of the sinus contents as possible from the paranasal sinuses. The operation usually has a good, but only short-term result. Systemic corticosteroid therapy is recommended in the postoperative period to prevent an early recurrence.

**Endoscopic interventions for fungal sinusitis of the maxillary sinus cavity.**

There are various oral corticosteroid regimens, but none of the publications on the treatment of allergic fungal sinusitis specifies the exact duration of prednisolone therapy, while most authors agree that the disease usually recurs after corticosteroid withdrawal. No more than half of the patients with this form of fungal sinusitis show lasting improvement after endonasal surgery combined with corticosteroid therapy.

Endoscopic access through the middle nasal passage is one of the most frequently performed for FESS. The nasal cavity is cleaned with gauze dampened with lidocaine and adrenaline. The hook-shaped process is removed with an anthrostomy through the middle nasal passage. Complete removal of the fungal masses through an uncinectomy and a sufficiently wide anthrostomy of the middle nasal passage.

A wide antrostomy promotes good visualisation of the maxillary sinus and easy passage of the surgical instruments. If the cells of the maxillary sinus are significantly blocked, an ethmoidectomy must be performed. After enlarging the opening in the maxillary sinus, the fungal body is removed using curved suction cups, forceps, and curved microdebrider blades.

"Gauze technique" is a simple and quick method of removing a fungal body in the maxillary sinus. It is a standard operation using traditional instruments and a gauze swab. The surgical procedure is performed as follows. After performing a wide antrostomy, the fungal body is removed using curved endoscopic pincers and suction.
Figure 2. Schematic localisation of the fungal body in the planning of the endoscopic access.

a) axial section; b) coronal section. The fungal body is localised near the osteomeatal complex. (NLD - nasolacrimal duct; IT - inferior turbinate; MT - middle turbinate; ES - ethmoidal sinus; MS - maxillary sinus.

A gauze swab soaked in standard saline solution is inserted into the maxillary sinus through the antrostomy. The main part of the gauze pushes out the remaining fungal masses using a curved suction cup or curved pincers, and then the gauze can be used to push the fungal body out of the antrostomy. The procedure is repeated several times, after which the gauze can easily be removed with curved forceps from the cavity (Fig. 2-3).

Figure 3. Scheme of combined access using a mesh.

(a) the accesses are made through the inferior meatal antrostomy; (b) and (c) the mesh pushes the fungal body out of the sinus through the middle nasal passage; (d) the fungal body is completely removed. (NLD, nasolacrimal duct; IT, inferior turbinate; MT, middle turbinate); ES, ethmoidal sinus; MS, maxillary sinus.
Figure 4: Schematic of the procedure for creating a flap in the inferior nasal passage.

a) U-shaped flap is formed at the bottom of the nasal cavity after bone elevation; b) the flap is formed along the edge of the "bone window" into the maxillary sinus after removal of the bone wall. (NLD, nasolacrimal duct; IT, inferior turbinate; MT, middle turbinate); ES, ethmoidal sinus; MS, maxillary sinus.

Even if the lower nasal antrostomy closes after surgery, which is not the main problem, a mucosal flap formation procedure is usually performed to avoid closure or stenosis of the antrostomy of the lower nasal passage. A U-shaped nasal flap is formed from the mucosa of the lower and lateral wall of the lower nasal passage. After the flap is formed, it is placed on the bottom of the nasal cavity. A window is then created using a perforator or chisel. The bone wall is removed piecemeal to make a hole wide enough in the maxillary sinus. When the bone is hard, it is better to form the opening using an angled drill. Once the opening is wide enough, the mucosa flap is placed across the lower edge of the bone window into the maxillary sinus. The contents of the maxillary sinus can easily be observed and surgical instruments can be inserted through the lower window or the middle passage (Fig. 4).

In a modified endoscopic medial maxillectomy, the head of the inferior nasal turbinate is cut off once using the nasal scissors up to the middle antrostomy of the nasal passage. This is done to
ensure sufficient visualisation of the sinus from the inferior passage. After sieving the preserved inferior turbinate to the posterior midline position, a medial maxillectomy is performed from the medial antrostomy with special forceps (Fig. 5-6).

**Figure 5.** Modified endoscopic medial maxillectomy.

Schematic of a case where the fungal body is located in the corner between the nasolacrimal duct and the anterior wall of the maxillary sinus. Access is via the anterior nasolacrimal duct. (NLD, nasolacrimal duct; IT, inferior turbinate; MT, middle turbinate); ES, ethmoidal sinus; MS, maxillary sinus.

After removal of the fungal body, the turbinate is moved and sutured to the anterior mucosa in its original position. These accesses are performed through the posterior part of the nasolacrimal duct. Because of this, it is difficult to obtain a sufficiently good visualisation of the fungal body located in the area between the nasolacrimal duct and the anterior wall of the maxillary sinus. In such difficult cases, endoscopic modified medial maxillectomy is the method of choice.
CONCLUSION

FESS is thus an effective treatment for non-invasive fungal rhinosinusitis, including fungal bodies of the PNS. Various surgical modifications involve the complete removal of fungal masses. It is important to perform a thorough cavity revision, which requires sufficient visualisation of the sinus. In the guidelines, the most optimal approaches, via the middle nasal passage, combined access via the middle and lower nasal passages, endoscopic medial maxillectomy, and endoscopic modified medial maxillectomy for fungal lesions of the maxillary sinus, were considered. It is important to understand the possible risks of these techniques in order to avoid complications with FESS.

REFERENCE


15. Tsuta Y., Murata K., Minamitani H. and Ohta F. Transsubmucosal Maxilloethmoid Sinus Surgery through Inferior Turbinate (Swinging of Nasolacrimal Duct and Inferior Turbinate).

