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Therapy of invasive mucoceles of the frontal sinus*

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SUMMARY

Mucoceles of the frontal sinus that extend into the orbits and the anterior cranial fossa can, in certain cases, be difficult to manage therapeutically and may lead to lethal complications. The surgeon will have to make a decision between an endonasal and an extranasal, transfacial procedure to provide an adequate access.

Between 1995 and 1998 we treated 12 patients suffering from invasive mucoceles of the frontal sinus. The mucocele was localized medially in 7 cases and in the lateral part of the frontal sinus in 5 cases. Five of the patients exhibited destruction of the orbital roof and in 7 cases combined destruction of the orbital roof and the floor of the frontal sinus were noted. The posterior wall of the frontal sinus was destructed in 6 patients, with one patient additionally showing partial destruction of the anterior frontal sinus wall. The causes of mucocele formation were previous frontal sinus operations (n=8) and frontal sinus fractures (n=3). In one case the cause remained unknown. In 7 cases with a medially localized mucocele the mucocele was marsupialized using an endonasal access. The mucoceles with a lateral localization were osteoplastically operated via an external access. Here we performed median drainage in 3 cases and, in one case each, obliteration and cranialization of the frontal sinus. The follow-up period was 2.8 years on average. All patients were free of complaints immediately after the operation. Mucocele recurrence or other complications did not arise. The cosmetic results were satisfactory in all cases.

Key words: mucocele, frontal sinus, surgical treatment

INTRODUCTION

Mucoceles of the paranasal sinuses are chronic expanding lesions filled with sterile mucus and shed epithelial cells. An increasing accumulation and retention of mucus develops when mucosal discharge is obstructed. This can lead to thinning and destruction of one or more walls of the paranasal sinuses. If the mucocele becomes infected, one speaks of a pyocele (Howarth, 1921).

Mucoceles mostly develop in the frontal sinus and less commonly in the ethmoid cell system or in the maxillary and sphenoid sinuses. The two most frequent causes of frontal mucoceles are: Inflammatory changes and posttraumatic or iatrogenically induced scarring of the nasofrontal duct. Evans reviewed 46 patients with fronto-ethmoidal mucoceles. Twenty-two (48%) of whom suffered prior nasal obstruction from polyps (Evans, 1981). In rarer cases benign tumors such as osteomas and fibrous dysplasia or metastatic malignant tumors can obstruct the infundibulum and give rise to mucocele development. In a variety of cases, however, the genesis remains un-clarified. Disturbances of secretion transport, pathologic pneumatization processes and atypical growth of mucosa due to enhanced bone resorption induced by increased fibroblast activity in association with increased formation of prostaglandins and leukotrienes have been discussed as possible causes (Lund et al., 1988).

By way of infection or as a result of their expansive growth mucoceles of the frontal sinus can give rise to intracranial and orbital complications. Surgical intervention is the only therapeutic option at hand. While mucoceles of the ethmoid cell system, of the maxillary and sphenoid sinuses can be marsupialized into the nose without problems through an endonasal access, the procedure adopted in the case of frontal sinus mucoceles is dependent on the localization and extent of the mucocele.

In the following we would like to report on our experience in the therapy of invasive frontal sinus mucoceles in 12 patients.

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Table 1. Therapy of invasive frontal sinus mucoceles (N=12).

patient	previous operations	chronic sinusitis	trauma	predisposing factors
1	-	-	+	-
2	EN (2)	+	-	MA, ASS-I
3	-	-	+	-
4	EX (1)	-	-	-
5	EX (2)	-	-	-
6	-	-	+	-
7	EN (1),EX (1)	-	-	-
8	EX (23)	-		-
9	EX (1)	-	-	-
10	EN (1)	+	-	MA,ASS-I
11	EN (1)	-	-	-
12	-	-	-	-

EN: endonasal operation of the frontal sinus, EX: extranasal operation of the frontal sinus,
MA: multiple allergies, ASS-I: aspirin intolerance

PATIENTS AND METHODS

Between 1995 and 1998 we treated 12 patients with invasive frontal sinus mucoceles.

The series comprised 9 men and 3 women with an age of 18 to 74 years (M=51.8). The mucoceles were localized in the medial part of the frontal sinus in 7 patients and in the lateral part in 5 cases. Eight patients had undergone previous frontal sinus surgery. One of the patients had been operated transfacially 23 times through an external frontoethmoidectomy incision (Table 1). Two patients exhibited a nasal polyposis with frontal sinusitis and multiple allergies and aspirin intolerance. In three patients the invasive mucoceles had developed over a period of 2, 18 and 25 years, respectively, after a fracture of the frontal sinus which had not been treated primarily. In one patient the cause of mucocele development could not be determined.

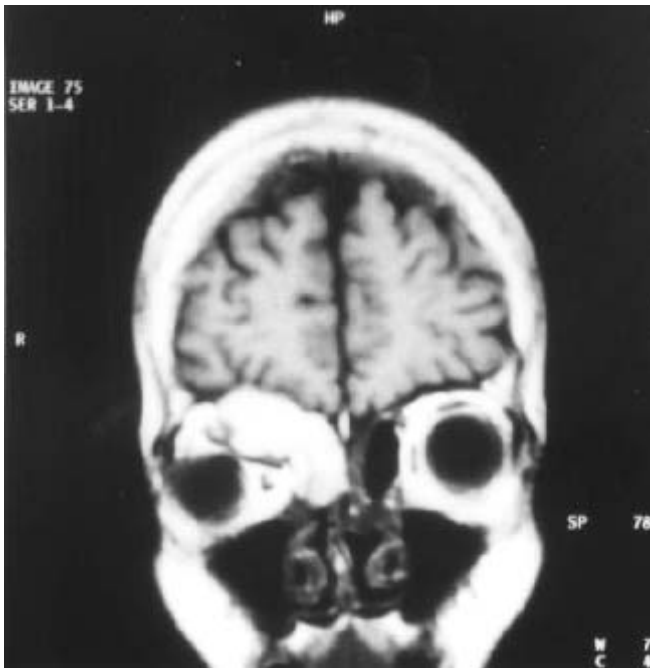
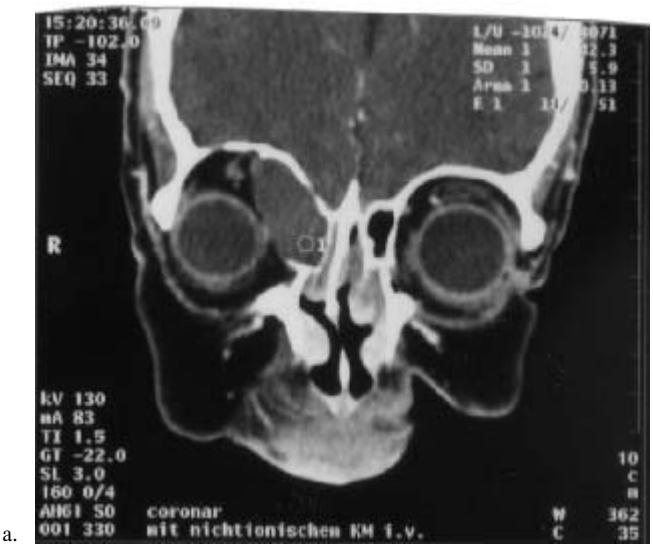
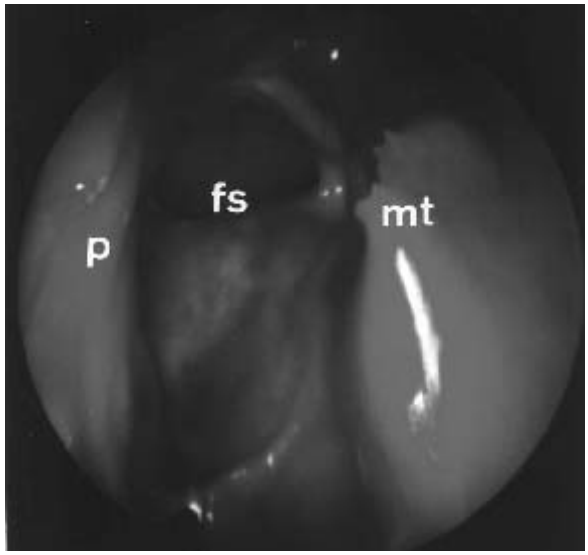


Figure 1. Magnetic resonance scan of a mucocele of the right frontal sinus with expansion into the orbit, nose and epidural space.
T1-weighted, coronal image.



a.



b.

Figure 2a-b. Mucocele of the right frontal sinus with intraorbital extension. Coronal CT, preoperatively (a). Endonasal endoscopic view 8 weeks postoperatively (b). fs: frontal sinus, mt: middle turbinate, p: periorbit.

The most frequent complaints reported by patients, independent of the localization and extent of the mucoceles, comprised the following: frontal cephalalgia (n=11), tenderness in the region of the forehead and orbits (n=8), diplopia (n=7) and obstructed nasal ventilation (n=4). In three cases periorbital swelling was present as well. Upon clinical examination 9 patients complained of tenderness above the forehead and in 5 cases proptosis was noted.

Computed tomography and magnetic resonance scans of the nasal sinuses were acquired in all cases. The images showed well demarcated, homogeneous masses that had led to the destruction of the bony boundaries of the frontal sinus. In 5 cases destruction of the orbital roof and in 7 cases combined destruction of the orbital roof and the floor of the frontal sinus were observed. The posterior wall was additionally destructed in 6 patients (Figure 1), one of whom also showed destruction of the anterior frontal sinus wall. Surgical sanitation of the mucoceles was carried out in all cases.

The medially localized mucoceles were opened via an endonasal access and marsupialized into the nose (Figure 2a-b). The option of an extranasal access was discussed with the patient in those cases in which it remained unclear preoperatively whether the mucoceles could be acceded endonasally. Anterior ethmoidectomy was primarily performed, under endoscopic control, and - once the roof of the ethmoid sinus, the anterior ethmoidal artery and the medial wall of the orbita had been identified - the mucocele was opened and the mucosal walls were endoscopically inspected. Sphenoethmoidectomy and, if necessary, maxillary sinus surgery were performed only in the event of an additional purulent or polypose affliction of the remaining paranasal sinuses.

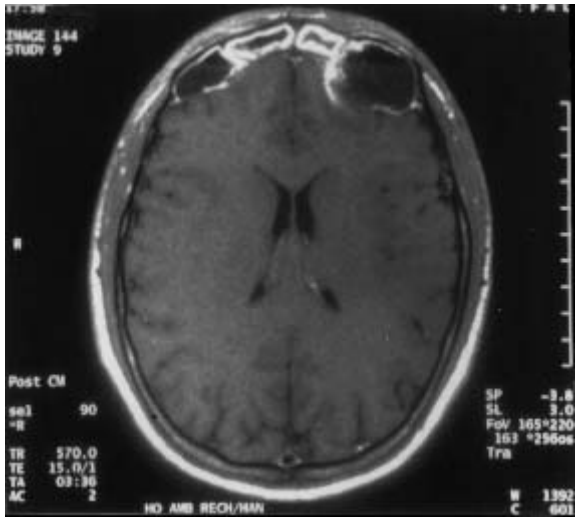
The laterally localized frontal sinus mucoceles that were not accessible by an endonasal route were operated extranasally using an osteoplastic access.

In all patients with ample hair growth the frontal sinus was exposed using a coronal incision. Further exposure of the frontal sinus after creation of a bone plate of the anterior frontal sinus wall was conducted according to the principles of the osteoplastic technique (Weber et al., 1995a). The mucoceles were then opened and, in three patients, drained into the nose through median drainage. This involved removal of the entire floor of the frontal sinus on both sides as well as the interfrontal septum and the perpendicular plate. In the one patient who had been operated on the frontal sinus transfacially 23 times we performed an obliteration of the frontal sinus with abdominal fat. Before this, the mucosa of the frontal sinus had been removed completely, under microscopic and endoscopic supervision, and the duct sealed with ear cartilage and a galeaperiosteum transplant.

In one patient showing extensive destruction of the posterior frontal sinus wall on both sides and extension of the bilateral mucoceles into the epidural space, cranialization of the frontal sinus was performed. The overall large frontal sinuses were exposed through a bifrontal craniotomy in cooperation with neurosurgeons.

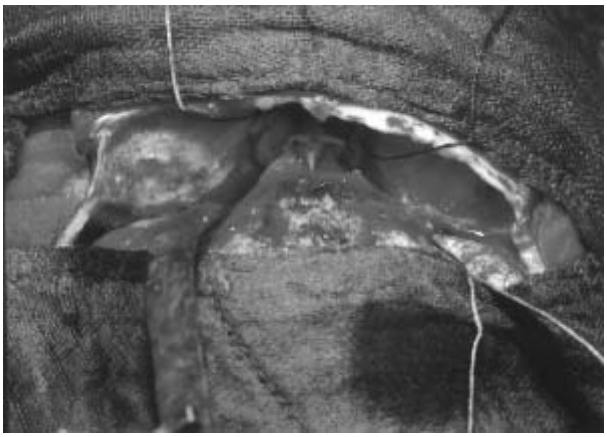
The wall and mucosa of the posterior frontal sinus were removed completely and the frontal sinus sealed off in the direction of the nose. The cavity formed between the dura and the anterior frontal sinus wall was obliterated with abdominal fat derived shortly before from the region of the navel (Figure 3a-d).

In one patient the defect of the anterior frontal sinus wall was reconstructed in one and the same session with a tabula-externa-transplant from the region of the parietal calotte. The tabula



a.

c.



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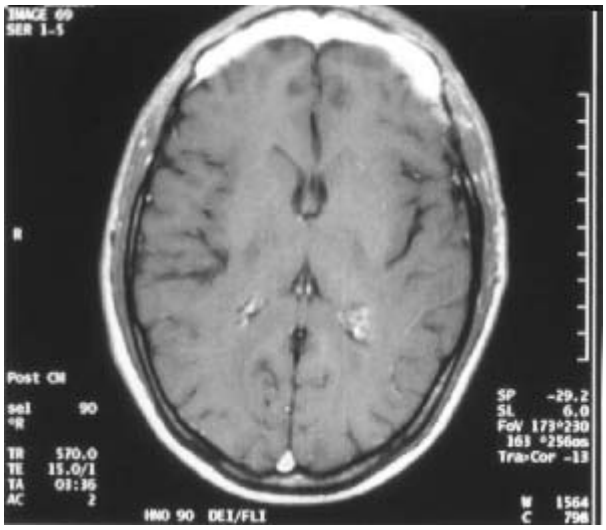

d.

Figure 3a-d. Bilateral mucoceles of the frontal sinus showing destruction of the posterior wall and epidural extension. Axial MRI, T1-weighted (a). Situation after bifrontal craniotomy and complete removal of the posterior frontal sinus wall and of the mucosa (b). Obliteration with abdominal fat of the dead space between the dura and the anterior frontal sinus wall (c). Axial MRI, T1-weighted, 1 year postoperatively (d).

externa was derived 1.5-2 cm lateral of the midline. This served to avoid damage to the superior sagittal sinus.

RESULTS

Follow-up was 2.8 years on average, ranging from 1 up to 4 years.

In patients who had undergone endonasal operations regular and careful postoperative, endoscopically supported follow-up was conducted over a period of 6-8 weeks during which fibrin deposits and crusts were removed and possibly occurring synechias were separated under local anesthesia.

This helped to maintain sufficient drainage of the frontal sinus. Additional diagnostic imaging (CT or MRI of the paranasal sinuses) was performed, 6-12 months postoperatively, in all patients who had not been operated endonasally.

All patients were free of complaints postoperatively and in no case were there any signs of late complications such as reduced vision, meningitis or rhinoliquorrhea. The cosmetic results were good, since operations had been carried out endonasally or - in the case of extranasal procedures - an access had been created via a coronal incision in all treated patients, thus avoiding the formation of unattractive scars in the face. Changes in the contours of the forehead did not arise.

DISCUSSION

Mucoceles of the frontal sinus were first described in 1725 by Dezeimeris (Berthon, 1880). In 1818 Langenbeck commented the clinical complaints and symptoms of mucoceles which he called hyatids (Langenbeck, 1818). It was Rollet who first used the term mucocele to describe these transformations (Rollet, 1896). In histopathologic terms a mucocele is a cystic cavity with mucoperiostal walls which are in turn lined with cuboid respiratory epithelium exhibiting chronic inflammatory alterations (McHenry et al., 1960).

The mucous retention cyst which is often used as a synonym has a different origin and pathenogenesis. A mucosa retention cyst develops after obstruction and dilation of a tubuloacinary gland. These cysts are often identified as coincidental findings in radiographs of the paranasal sinuses in which they stand out as well demarcated, rounded opacifications in the area of the floor of the maxillary sinus. If they are asymptomatic, they do not need to be therapied.

The complaints of patients with a mucocele of the frontal sinus vary and depend on the localization and growth behavior of the mucocele. If the mucocele does not transgress the frontal sinus boundaries, frontal cephalalgias and varying frontal tenderness above the mass represent the most frequent complaints. Frontal cephalalgia was the most common complaint among 56 patients with mucoceles of the frontal sinus reported by Bordley and Bosley. It occurred in 54 of 56 cases (Bordley and Bosley, 1973). Eight of the 9 patients with invasive frontoethmoidal sinus mucoceles reported by Stiernberg et al., described frontal pain as their chief complaint (Stiernberg et al., 1986).

If the contents of the mucocele become infected, local and systemic signs of inflammation appear. The continuous secretion of mucus causes an increase in pressure, leading to osteolysis and devascularization of the bone. Moreover, osteolytic mediators within the mucocele appear to be responsible for the aggressive nature of the mucoceles (Lund et al., 1993).

Mucoceles of the frontal sinus can extend downward into the orbits, the adjacent paranasal sinuses and the nasal cavity, back into the anterior cranial fossa, and forward into the soft parts of the forehead and the upper eyelid region. If intraorbital growth develops as a consequence of destruction of the orbital roof, diplopia, proptosis and bulb motility disturbances occur. While lesions of the optic nerves occur more frequently in mucoceles of the sphenoid sinus and the posterior ethmoid, loss of vision is found very rarely in mucoceles of the frontal sinus and the anterior ethmoid. Compression of the optic nerve with associated injury to the blood vessels and the spread of infection with neuritis of the optic nerve are considered to be the causes of this condition (Fujitani et al., 1984). The prognosis of visual function depends on the duration of injury (Fujitani et al., 1984).

Destruction of the posterior frontal sinus wall results in a direct connection between the mucocele and the epidural space. Although the dura can withstand the pressure exerted by the mucocele and is resistant to possible infection, intradural growth with severe complications like liquor flow, meningoencephalitis and pneumocephalus can develop in very rare cases (Koike et al., 1996).

Computed tomography (CT) is currently the diagnostic method of choice for paranasal sinus pathology. On the basis of three-dimensional reconstructions the localization and extent of a mucocele can be precisely determined and possible bone arrosion diagnosed. Moreover, the surgeon obtains important information on the individual anatomy of the frontal sinus and the other paranasal sinuses. This knowledge is an important prerequisite for planning surgical interventions. Magnetic resonance imaging (MRI) is very helpful in differentiating mucoceles from meningo-encephaloceles and tumors and in demarcating mucoceles and soft-tissue structures in the event of intracranial or intraorbital growth.

Surgical intervention represents the only therapeutic option. The choice of adequate surgical access depends on the localization and extension of the mucocele. Furthermore, the individual anatomy - including modifications resulting from earlier operations - as well as the provision of thorough and long-term follow-up and after-care for the patient play an important role in avoiding recurrences.

In our experience most mucoceles develop in the medial part of the frontal sinus.

In most cases the causes are to be found in earlier endonasal or extranasal frontal sinus operations and in pronounced development of nasal polyposis which can lead to scarring or obstruction of the nasofrontal duct and the frontal recess.

In these cases endonasal, endoscopically and microscopically supported marsupialization of the mucocele into the nose represents the method of choice. This approach allows the normal mucosa and possibly the still existing bony boundaries of the frontal sinus infundibulum to be preserved to a large extent (Iro and Hosemann, 1993). For the patient the intervention

bears little discomfort and the complication rate is low (Kennedy et al., 1989; Wigand and Hosemann, 1991). Due to the enhanced accuracy and safety of the available auxiliary optical instruments the local findings can be endoscopically monitored postoperatively in the ethmoid and also in the frontal sinus without problems (Hosemann et al., 1992; Benninger and Marks, 1995).

If the mucocele of the frontal sinus cannot be acceded through an endonasal access and if a lasting drainage function thus cannot be guaranteed, an extranasal, transfacial procedure is indicated.

Important objectives of operative therapy should encompass the following:

1. Reliable sanitation of the mucocele of the frontal sinus including, if necessary, the management of intracranial and intraorbital complications.
2. Drainage of the mucocele into the nose, either by preservation or extension of the natural frontal sinus infundibilum or complete removal of the mucocele and the mucosa of the frontal sinus and reliable closure of the frontal infundibulum.
3. Preservation or reconstruction of the anterior wall of the frontal sinus to protect the frontal brain and reconstitution of the contour of the forehead.

After osteoplastic incision of the frontal sinus the adopted course of the procedure depends on the individual anatomy and history of the patient, as well as on the overall pathological condition of the mucosa of the nasal and paranasal sinuses.

In the event of a frontal sinus of overall small proportions, a non-significant history and otherwise inconspicuous mucosal conditions, we drain the mucocele into the nose by applying median drainage. Here damage to the mucosa in the region of the posterior wall of the frontal sinus and the infundibulum is avoided as far as possible so as to prevent stenosis development caused by circular scar formation.

The danger of a recurrent mucocele is distinctly increased in cases involving invasive mucoceles located far laterally and behind a narrow recess, in patients having undergone a transfacial frontal sinus operation (using the Killian or Lynch-Howarth procedure) and in patients requiring recurrent surgery who exhibit predisposing factors such as analgesics intolerance (Schaefer and Close, 1990). In our experience, obliteration of the frontal sinus has proven successful in such patients.

The success of obliteration depends on the careful extirpation of the mucosa, permanent closure of the nasofrontal duct and the choice of appropriate obliteration material. Complete removal of the mucosa cannot be achieved solely by ablating the mucosa, as growth of the mucosal tissue can reach into recesses and fissures of the bone (Donald, 1979).

The inner bone layer should therefore always be additionally ground away with a bur. The microscope is an indispensable tool when it comes to reliably removing the mucosa from the dura and the periorbits. Closure of the nasofrontal duct aims to prevent an ascending frontal sinus infection and displacement of transplanted material into the nose. Moreover, the growth of nasal mucosa upwards in the direction of the frontal sinus is prevented. To date there exists no ideal obliteration material. Fat, which is most widely used for obliteration, is associated with a varying degree of necrosis, resorption and reconstruction of connective tissue (Smahel, 1989; Weber et al., 1995b).

If large portions of the posterior frontal sinus wall are destructed in association with substantial epidural spread of the mucocele, or if intracranial complications are present, we perform cranialization of the frontal sinus by completely removing the posterior wall. These cases require the cooperation of a neurosurgeon and possibly the creation of an osteoplastic access by frontal craniotomy (Denneny and Davidson, 1987).

Occasionally it may also be necessary to partly or completely remove the posterior frontal sinus wall in the framework of a planned obliteration procedure. Only in this way is it possible to retract the meninx so as to ensure complete removal of the mucosa from recesses reaching as far as the lesser wing of the sphenoid.

An extradural dead space is formed once the posterior frontal sinus wall has been removed. This space is obliterated by expansion of the frontal brain within a period of several weeks or months. In children the filling of this dead space is attained after 7 days at the earliest, which is much faster than in adults (Spinelli, 1994).

To achieve immediate closure of this dead space and to avoid scarred adhesions between the dura and the anterior wall of the frontal sinus we seal the extradural dead space with abdominal fat after every cranialization of the frontal sinus. The fat forms a soft buffer zone between the dura and the anterior frontal sinus wall. This zone gradually becomes smaller due to a partial transformation into scar tissue.

The condition and vitality of the fatty tissue, as well as the extension of the frontal brain can be postoperatively assessed by magnetic resonance tomography of the paranasal sinuses (Weber et al., 1995b). Overall, long-term results are a prerequisite for reliable assessment of frontal sinus interventions, since recurrences or complications can still develop many years after primary surgical intervention. Especially in the context of invasive frontal sinus mucoceles a potential recurrence should be treated as early as possible due to the danger of lethal complications. Therefore we recommend control MRI scans 1, 2, and 5 years after surgery or immediately when symptoms recur.

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