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From Sinus to Brain: Frontal Mucocele Complicated by Intracranial Empyema

M. Boussif[1*], A. Bouelhaz[1], Y. Bouktib[1], A. El Hajjami[1], B. Boutakioute[1], M. Ouali Idrissi[1], N. Cherif Guennouni Idrissi[1]

[1]Department of Radiology, Arrazi Hospital, University Hospital of Mohamed VI, Marrakech, Morocco

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***Corresponding author:** M. Boussif
Department of Radiology, Arrazi Hospital, University Hospital of Mohamed VI, Marrakech, Morocco

Abstract **Case Report**

Mucoceles of sinuses are benign, expansile pseudo-cystic lesions that are typically develop slowly and often present with neurological or ophthalmological complications. We report the case of a 20-year-old male with a frontal mucocele exhibiting intracranial extension. The patient presented with a 3-week history of left-sided frontal swelling accompanied by worsening headaches. Computed tomography (CT) confirmed the presence of a frontal mucocele with significant bone erosion and an associated intracranial empyema. Surgical intervention resulted in a favorable outcome with complete resolution of symptoms. Frontal and fronto-ethmoidal mucoceles, although benign, can cause serious complications, including orbital and intracranial involvement if left untreated. Imaging, particularly CT and MRI, plays a vital role in diagnosis, preoperative planning, and post-treatment monitoring. Surgical management is the treatment of choice, with recurrences being rare. Early detection and management are essential for preventing functional and life-threatening complications.

Keywords: Frontal Mucocele, Intracranial Extension, Imaging, CT Scan.

INTRODUCTION

Mucoceles of the sinuses are benign, expansile cyst-like lesions resulting from ostial obstruction and the gradual accumulation of mucoid secretions and desquamated epithelium [1]. The most common cause of sinus mucocele is iatrogenic, particularly following endonasal surgery [2].

While mucoceles can occur at any age, they are most frequently observed between the fourth and seventh decades of life, affecting both sexes equally [3]. They typically develop in the frontal and ethmoid sinuses [4, 5]. Despite their histological benignity, mucoceles are aggressive and destructive lesions, with the potential to extend into orbital and intracranial structures.

The clinical presentation of mucoceles varies depending on the affected sinus, the size of the lesion, the extent of local involvement, and any complications that arise [6]. The progression of mucoceles is usually slow, and they are often asymptomatic, which can lead to a diagnostic delay. As a result, these relatively rare tumors are frequently diagnosed only once serious orbital or intracranial complications have developed [7].

Computed tomography (CT) and magnetic resonance imaging (MRI) are the preferred imaging techniques for diagnosing mucoceles and determining the underlying cause of obstruction. Both modalities play complementary roles: CT is useful for assessing the regional anatomy and extent of the lesion, particularly with regard to intracranial extension and bone erosion, while MRI helps differentiate mucoceles from neoplasms and can identify an underlying tumor that may be causing the obstruction [8].

Surgical intervention remains the treatment of choice, typically involving decompression, drainage, and wide marsupialization of the mucocelic cavity. Recurrences have been observed approximately 3 to 4 years post-treatment [9].

CASE PRESENTATION

A 20-year-old male patient who presented with a 3-week history of left-sided frontal swelling and worsening headaches, exacerbated when bending forward. Clinical examination revealed a soft, non-tender, and slightly fluctuating mass over the left frontal

region. While the patient was hemodynamically and respiratorily stable, laboratory tests showed an elevated white blood cell count at 11000 and C-reactive protein at 68, indicating an inflammatory process.

An ultrasound of the frontal region identified a well-circumscribed, fluid-filled lesion consistent with a mucocele. The ultrasound showed a hypoechoic mass with some areas of heterogeneous echogenicity, suggesting a complex cystic structure. Doppler imaging showed no significant vascularity, supporting its benign nature, though adjacent soft tissue edema was noted. (Figure 1).

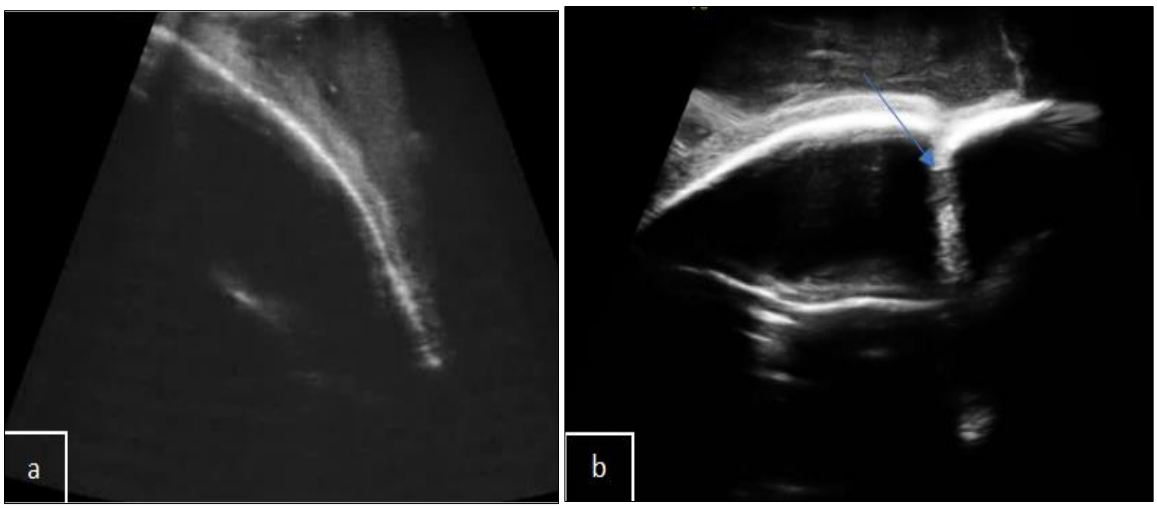

Figure 1: Ultrasound images of the frontal region in coronal (a) and axial (b) plans, showing a well-defined hypoechoic lesion with areas of heterogeneous echogenicity, consistent with a complex cystic structure suggestive of a mucocele, with a petrous channel (blue arrow) connecting the mucocele to the intracranial

Imaging studies, including a contrast-enhanced CT scan, confirmed a frontal mucocele with destructive involvement of the posterior wall of the frontal sinus, causing a scaloping effect on the anterior wall. (Figure 2) It was responsible for a bulging of the cortical bones with bone erosion of the walls of the homolateral frontal sinus. (Figure 3)

The mucocele was complicated by a cerebral empyema and a left-sided subcutaneous frontal collection, which communicated with the mucocele through a petrous channel. Additionally, pansinusitis was observed, further complicating the clinical picture.

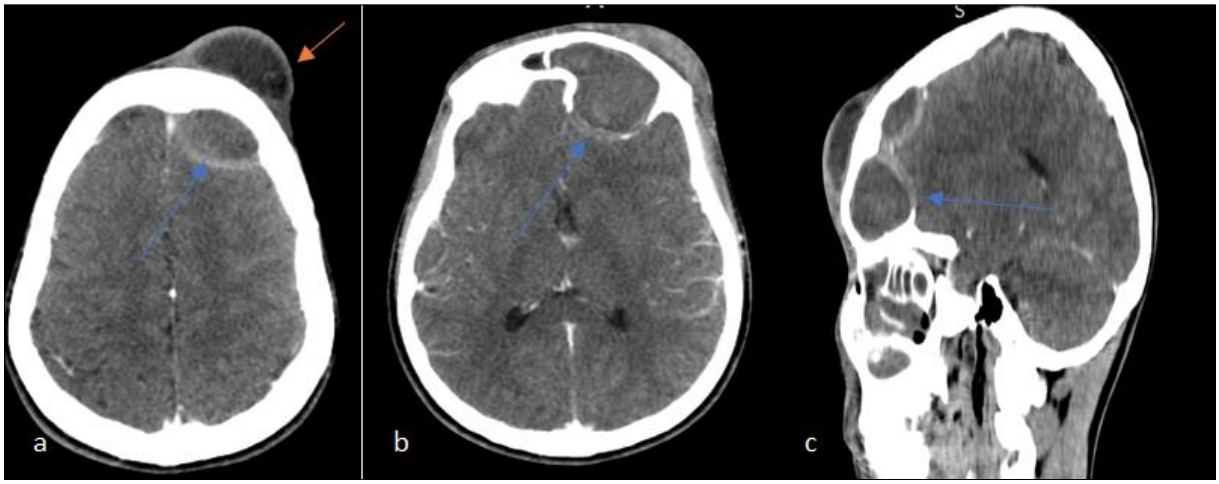

Figure 2: Head CT scan, axial (a) without contrast, axial (b) and sagittal (c) with contrast, showing a frontal mucocele (orange arrow) with destructive involvement of the posterior wall of the frontal sinus, causing a scalloping effect on the anterior wall. The mucocele was complicated by a cerebral empyema (blue arrow) and a left-sided subcutaneous frontal collection, which communicated with the mucocele through a petrous channel

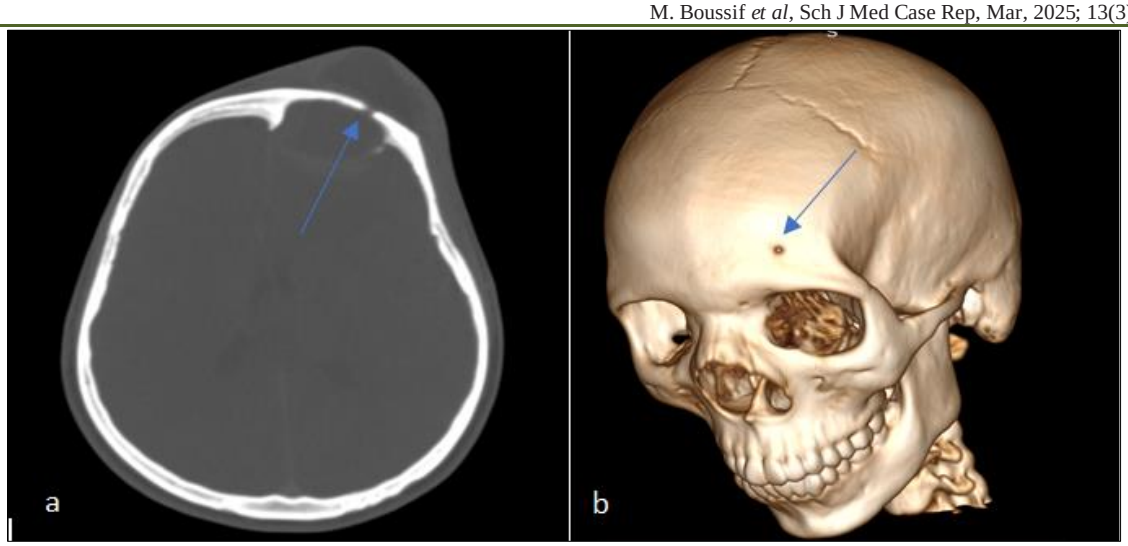

Figure 3: Head CT, bone window, axial plan (a) and 3D reconstruction (b) showing bulging of the cortical bones with bone erosion of the walls frontal sinus, and a petrous channel (blue arrow) communicating the mucocele with the empyema

The radiologist concluded a left frontal mucocele with intracranial extension, accompanied by significant bone erosion. According to the classification proposed by Thiagarajan [10], it was categorized as type IIIb.

A frontal mucocele with intracranial extension was the retained diagnosis, and surgical excision of the lesion was subsequently performed. Histopathological analysis validated the diagnosis.

At follow-up, the patient experienced favorable outcomes, including resolution of headaches and the regression of frontal swelling. One month after surgery, the patient's symptoms had significantly improved, with no recurrence of the mucocele. The patient continues to be monitored regularly.

DISCUSSION

Mucoceles are benign, expansile pseudocystic lesions, that typically result from sinus ostium obstruction due to various underlying causes, such as chronic inflammation, craniofacial trauma, nasal polyps, benign neoplasms, or even malignant tumors [1-8]. The etiology remains somewhat unclear, though an increasing body of literature suggests that iatrogenic causes, particularly post-surgical or post-traumatic, play a significant role [2-11]. Spontaneous mucoceles, however, have also been reported in the absence of identifiable predisposing factors [12].

The incidence of mucoceles has been on the rise, largely due to advancements in imaging techniques, particularly endoscopic and radiological investigations, which allow for earlier diagnosis and better detection of lesions that might have been missed in the past [13]. Though they can develop at any age, mucoceles are most commonly diagnosed in adults between the ages of 40 and 70, affecting both males and females equally [3].

Frontal sinus mucoceles are the most common, accounting for 70-80% of cases, followed by ethmoidal (25%), and maxillary sinuses (less than 3%). The sphenoidal sinus is rarely involved [14]. The higher prevalence in the anterior ethmoid cells can be attributed to their smaller size and narrower ostia, which are more prone to obstruction and chronic inflammation [15]. Mucoceles of the fronto-ethmoidal complex are also frequently observed together, illustrating the interconnected nature of the sinuses. [16].

The pathophysiology of mucoceles is driven by obstruction of the sinus ostium, typically resulting from chronic inflammation. This leads to continuous mucous secretion, with subsequent expansion of the lesion and potential erosion of surrounding bone structures, which may cause involvement of adjacent anatomical areas such as the orbit or the intracranial space. Such expansions can result in significant complications, including proptosis, visual disturbances, and even intracranial infections such as meningoencephalitis or brain abscesses [17].

Clinically, mucoceles may remain asymptomatic until they grow large enough to exert pressure on adjacent structures. Common symptoms include orbital and naso-sinusal manifestations, such as headaches, facial asymmetry, visual disturbances, and, in more severe cases, proptosis, diplopia, or vision loss [18]. These signs are often seen in conjunction with expanding lesions in the fronto-ethmoidal region. The direction of proptosis can often provide insight into the location of the involved sinus, with lesions from the orbital apex causing forward displacement, and those from the fronto-ethmoidal region pushing the eye laterally and downward [3].

Erosion of the posterior wall of the frontal sinus can result in intracranial complications such as meningoencephalitis, pneumocephalus, brain abscess and empyema, seizures, or cavernous sinus fistula [19]. The posterior sinus wall is especially susceptible to erosion due to its inherent thinness. The risk of bony erosion and intracranial or orbital extension increases in the setting of acute infection of mucoceles (mucopyocele).

From a radiological standpoint, both CT and MRI play crucial roles in diagnosing and managing mucoceles. CT scans are considered the gold standard for the initial diagnosis due to their ability to visualize bone erosion and the exact extent of the lesion. On CT, mucoceles typically appear as isodense masses with attenuation values between 10 and 40 HU, reflecting their mucous content. The presence of peripheral enhancement is suggestive of infection or inflammation within the mucocele. Additionally, CT is invaluable for assessing bone involvement and any extension into the orbit or intracranial space [8-20].

Mucoceles may also contain non-enhancing hyperdense stippled areas resembling fine calcifications, which represent inspissated, dehydrated mucocele content [21].

CT is the preferred modality for assessing bone erosion and evaluating intracranial and intra-orbital extension.

In total, three key CT criteria for diagnosing a mucocele include a homogeneous isodense mass, well-defined margins, and patchy osteolysis around the lesion. Sinus wall erosion with marginal sclerosis is also a suggestive finding [22].

MRI is particularly useful for differentiating mucoceles from other sinus tumors, providing detailed information on the signal characteristics of the lesion. On T2-weighted images, mucoceles typically exhibit high intensity, indicative of their high water content, while on T1-weighted images, they show low to high intensity, reflecting variations in mucus viscosity and protein content [16]. Post-contrast imaging is crucial, as mucoceles should show little to no enhancement, distinguishing them from tumors or other pathologies [23]. However, in cases with proteinaceous content or complicated mucoceles, both CT and MRI may be required to provide complementary information for an accurate diagnosis.

The radiological differential diagnoses of mucoceles include dermoid cysts, histiocytosis, fungal and tuberculosis infections, fronto-orbital cholesterol granuloma, and other rare neoplasms. Differentiation is typically straightforward on MRI due to the higher T1-weighted hyperintensity of other lesions [24].

Thiagarajan [10] classified frontal and fronto-ethmoidal mucoceles into five types based on their extent:

- Type I: Confined to the frontal sinus, with or without orbital extension.
- Type II: Involves both frontal and ethmoidal sinuses, with or without orbital extension.
- Type IIIa: Erodes the posterior wall of the frontal sinus, with minimal or no intracranial involvement.
- Type IIIb: Erodes the posterior wall with significant intracranial extension.
- Type IV: Erodes the anterior wall of the frontal sinus.
- Type Va: Erodes both walls with minimal intracranial extension.
- Type Vb: Erodes both walls with significant intracranial extension.

Surgical treatment is the mainstay of therapy, with endoscopic approaches increasingly preferred due to their lower morbidity and better outcomes compared to external approaches. The aim of surgery is to drain the mucocele, remove the obstruction, and re-establish normal sinus ventilation. In cases of infection or complications, antibiotics may be necessary [15-22]. Recurrence is uncommon but can occur, particularly in cases with incomplete surgical removal or poor sinus drainage [9]. When managed early, mucoceles generally have a good prognosis, though delays in treatment can lead to significant complications, including intra-orbital or intracranial involvement [25].

CONCLUSION

Mucoceles are rare, benign lesions, often affecting the frontal and fronto-ethmoidal sinuses. Their potential to damage adjacent structures can have significant functional and prognostic implications. CT and MRI are key diagnostic tools, each offering distinct advantages and complementary roles in evaluating sino-nasal pathology.

On CT, mucoceles appear as homogeneous, isodense masses with clear margins and associated osteolysis, while MRI shows hyperintensity on T2 and hypo to high intensity on T1, without contrast enhancement.

Advances in imaging and surgical excision of the lesion or endonasal surgery have improved their management.

Conflicts of Interest: The authors declare no conflicts of interest.

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