Delayed Post-Traumatic Fronto-Ethmoidal Sinus Mucocele Evaluated with Short and Long TE MR Spectroscopy

GAYANE AGHAKHANYAN^{1,2}, GIANCARLO LUPI³, FRANCESCA FRIJIA², HANA HLAVATA², FRANCESCO LOMBARDO², SARA DE CORI², RAFFAELLO CANAPICCHI², RICCARDO VANNOZZI³, DOMENICO MONTANARO²

¹Institute of Life Sciences, Scuola Superiore Sant'Anna; Pisa, Italy

²Neuroradiology Unit, CNR/Tuscany Region G. Monasterio Foundation; Pisa, Italy

³Section of Neurosurgery, Department of Neuroscience, Pisa University Hospital; Pisa, Italy

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SUMMARY – *Mucoceles are slow-growing, benign, expansile, mucoid-filled masses developing after obstruction of the sinus ostium. Late post-traumatic mucoceles are relatively rare entities and the literature is limited to single case reports. We describe an unusual case of post-traumatic fronto-ethmoidal mucocele, evaluated with computed tomography (CT), magnetic resonance imaging (MRI) and proton MR-spectroscopy (¹H-MRS). As a contribution to the diagnostic work-up of the mucocele, ¹H-MRS demonstrates a dominant peak at 2.0 ppm at long echo time (TE) and an additional component at 3.8 ppm at short TE due to mucus glycoprotein compounds of the mucocele.*

Introduction

Mucoceles are benign expansile lesions found in the paranasal sinuses and consist of mucus lined by pseudo-stratified respiratory epithelium¹. Although mucoceles are rare in adults, they most commonly involve the frontal sinus². The most frequent causes of mucocele formation include a history of sinusitis, previous sinus surgery and trauma³. In addition, benign tumors such as osteomas and fibrous dysplasia, or malignant and metastatic tumors can obstruct the sinus ostium and lead to mucocele development^{4,5}. This may evoke diagnostic discrepancy as the neuroradiological characteristics of mucoceles may be quite variable. Currently, computed tomography (CT) is the diagnostic method of choice for paranasal sinus pathology, while magnetic resonance imaging (MRI) is helpful in differentiating mucoceles from meningo-encephaloceles and tumors⁶. We describe a rare case of a post-traumatic fronto-ethmoidal mucocele that developed 49

years after initial trauma. In the setting of post-traumatic residual changes, *in vivo* proton magnetic resonance spectroscopy (¹H-MRS) at short and long echo time (TE) contributed to the diagnostic workup of the fronto-ethmoidal mucocele.

Case Report

A 72-year-old man presented with a headache that had been ongoing for two weeks before administration. He had a history of craniofacial trauma, dating almost 49 years ago, with a right ethmoid bone fracture following a motorbike accident. On admission, the patient's clinical examination and laboratory investigations were normal. General condition was good with no fever. The patient was submitted for a neuroimaging investigation. Written informed consent and local ethical committee approval was obtained prior to the study according to the Declaration of Helsinki.

Figure 1 A 72-year-old man with headache and a history of faciocranial trauma 49 years before. CT scans: axial direct acquisition (A,B) and axial (C,D) bone images. Right frontal sinus polycyclic and partially calcified (see black arrow) mass extended to the ethmoid upon a fracture line of the skull base.

Neuroimaging Findings

A brain computed tomography (CT) scan revealed parenchymatous homogeneous masses in the right frontal sinus, extending to the ethmoidal cells, following a frontal skull base fracture line, occupying the intracranial extracerebral spaces (Figure 1). The magnetic resonance imaging (MRI) examination performed on a 3T field strength system (Excite HDx GE

Healthcare, Milwaukee, WI, USA) showed an extra-axial polycyclic mass, surrounded by residual post-traumatic encephalomalacia and gliosis in the contiguous right orbitofrontal circumvolutions; one small apparently isolated cystic component was localized on the same side more laterally (Figure 2E,F). Most of the masses were hyperintense on T1-weighted images (Figure 2B), also applying fat suppression techniques (Figure 2E), and with an interme-

Table 1 Summary of previously reported post-traumatic mucocele cases in the paranasal sinuses.

<i>Author</i>	<i>Reported cases</i>	<i>Trauma</i>	<i>Years after trauma</i>	<i>Sinus localization</i>
Park et al., <i>J Oral Maxillofac Surg</i> 2012	1	frontal sinus fracture	30	frontal with orbital involvement
Rosado et al., <i>J Craniofac Surg</i> 2011	1	frontal sinus fracture	19	frontal
Mourouzis et al., <i>J Oral Maxillofac Surg</i> 2008	1	frontal injury	50	frontal
Hwang et al., <i>J Craniofac Surg</i> 2008	1	frontal sinus fracture	8	frontal
Hamilton et al., <i>Ear Nose Throat J</i> 2007	1	cranio-facial injury	10	ethmoidal
Cultrera et al., <i>J Craniomaxillofac Surg</i> 2006	1	frontal injury	9	frontal
Malloy et al., <i>Optometry</i> 2006	1	sinus surgery	9	fronto-ethmoidal
Nkenke et al., <i>J Craniomaxillofac Surg</i> 2005	1	midfacial fracture	16	maxillary
Billing et al., <i>Ophthalmic Surg Lasers Imaging</i> 2004	2	facial fracture	NA	maxillary
Koudstaal et al., <i>Int J Oral Maxillofac Surg</i> 2004	3	frontal sinus fracture	13; 22; 35 respectively	frontal
Smoot et al., <i>J Craniofac Surg</i> 1995	1	facial fracture	14	frontal

diate signal on T2-weighted (Figure 2A) and diffusion-weighted images (DWI). On T2* images, part of the lesion presented suffuse linear intensity (Figure 2D), corresponding to calcifications on CT images (Figure 1). Intravenous paramagnetic contrast injection revealed thin peripheral linear enhancement, with a persistent central high signal on T1-weighted images, both without (Figure 2C) and with fat suppression techniques (Figure 2F).

Single voxel proton MR spectroscopy (¹H-MRS) was sampled inside the largest nodule (TR = 2000ms; TE = 35/144 ms, respectively for short and long echo time; voxel size 15×15×15 mm; FOV 24 cm). Dedicated semi-automated software for ¹H-MRS post-processing (Functool, Version 8.3, GE Healthcare) on short and long TE acquisition revealed a large dominant peak at 2.0 ppm, mimicking cerebral N-acetyl-aspartate (NAA), without other peaks in the precession frequency of metabolites indicative of brain tissue, such as creatine (Cr) and choline (Cho) (Figure 3B, 3C). The short TE ¹H-MRS sampling (Figure 3B), used to exclude the presence of a myo-inositol peak (mI), revealed a large broad component at 3.8 ppm.

Based on negative laboratory results, imaging characteristics and a history of trauma, a presumptive diagnosis of post-traumatic fronto-ethmoidal sinus mucoceles was suggested and the patient underwent right supra-orbital craniotomy for removal of the lesions.

Surgery

In the prone position, the patient's head was fixed with a Sugita skull clamp. The head was rotated 30 degrees to the left, tilted laterally and raised above heart level; no extension was required. A right lateral supra-orbital approach was performed⁷. A small right frontotemporal incision with a single layer skin muscle flap was made and anteriorly retracted. A single burr hole was placed on the upper temporal line and supra-orbital craniotomy was performed. A sub-frontal route was decided and the inferior wall of the ipsilateral frontal lobe was gently retracted. A largely grey and soft space-occupying lesion was discovered originating from the anterior cranial fossa, through an old fracture of the ethmoid bone. A cleavage plan from the surrounding

Figure 2 MRI images: axial T2-weighted (A); pre-(B) and post-contrast (C) axial T1-weighted; axial gradient-echo T2*-weighted (D); coronal pre-(E) and post-contrast (F) T1-weighted with fat suppression technique. Right frontal sinus extra-axial soft tissue polycyclic mass, surrounded by post-traumatic residual alterations of cerebral frontal lobe (A,B), with an additional small lateral component (E,F). All nodules appear hyperintense on pre-contrast T1 images (B), also with the fat suppression technique (E), associated with microcalcifications inside and along the masses (D). Thin peripheral linear enhancement with central low-signal intensity on post-contrast T1-weighted images without (C) and with the fat suppression technique (F).

nervous tissue was recognized and a total resection was obtained. Ethmoidal opened cells were filled with temporal muscle and fibrin glue. The bone defect was then repaired with a dural substitute patch and covered with fibrin glue again. The dura was then sealed and the operculum was attached to the skull with titanium plates.

Histological Findings

A histological examination of the surgical specimen consisted of typical columnar epithelium lined by mucous cystic structure, with variable density of fibrous connective tissue and calcification. No microorganisms were identified and no evidence of neoplasia was noted (Figure 4).

Outcome and Follow-up

The postoperative course was uncomplicated and the patient was discharged 72 hours later. Neither residuals, nor recurrence of fronto-ethmoidal mucocoele was detected after six month MRI follow-up (not shown).

Discussion and Conclusion

Post-traumatic mucocoeles are rare entities and may occur several years after initial trauma³. As a consequence, the scientific literature is limited to single case descriptions (Table 1). Frontal and ethmoidal sinus mucocoeles may be clinically silent. Patients may

Figure 3 *In vivo* placement of a single voxel ¹H-MR sampling (white box in A) on T1-weighted sagittal MR image (A) and corresponding short (35 ms) (B) and long TE (144ms) (C). The X-axis represents precession frequency in ppm. Dominant peak at 2.0 ppm on short and long TE, with an additional board peak at 3.8 ppm at short TE (B). None of the usual brain metabolites (Cho, Cr, ml) were detected.

Figure 4 Microphotography of the surgical specimen. Hematoxylin-eosin stain: original magnification × 100 (A); original magnification × 400 (B). Cystic lesion lined by ciliated pseudo-stratified and stratified squamous epithelium consistent with a diagnosis of mucocele.

complain of headaches, swelling, dizziness, and nasal symptoms, such as obstruction and mucopurulent rhinorrhea⁸. Ophthalmic symptoms, such as pain, proptosis, diplopia, exophthalmos, globe displacement, decreased visual acuity, or epiphora manifest with expanding mucocoeles. Very rarely, due to intracranial extension meningitis, brain cerebrospinal fluid fistulas or abscesses may occur⁹.

Usually, CT scans demonstrate a homogeneous and airless mucoid density filled, expansile, non-enhancing sinus mass with gradual thinning and erosion of the bony margins⁸. MRI exhibits variable signal intensities on both T1- and T2-weighted images, depending on the state of hydration, protein content and viscosity of the contents of the mucocele. A high

water content results in low T1 signal and high T2 signal, whereas high protein content results in high T1 signal and low signal on T2 with inspissated mucus⁶. Diffusion-weighted signals and the apparent diffusion coefficient (ADC) values in a mucocele are variable depending on the viscosity of the fluid in the mucocele. Contrast-enhanced MRI is useful in differentiating mucocoeles from sinonasal tumors. Mucocoeles characteristically reveal a thin peripheral linear enhancement with central low-signal intensity on T1-weighted images, whereas sinonasal tumors demonstrate diffuse enhancement⁶.

¹H-MRS enables *in vivo* sampling metabolic constituents of a normal human brain. Using long TE (144 ms), metabolites such as Cr, Cho and NAA are detected. In addition, com-

pounds such as lactate, alanine, or others may be detectable if their concentration is elevated above normal levels due to pathological conditions. With short TE (35 ms), compounds with shorter T2 relaxation times also become detectable, such as glutamate, glutamine, and mI, as well as lipids and macromolecules. In our case, we performed MR spectroscopy on a 3T field strength system, both with long (144 ms) and short (35 ms) TE. We did not expect to reveal metabolic profiles of normal brain parenchyma, as the masses were in the extra-axial space and the voxel of interest was placed preferentially within the lesion (Figure 3A). Long TE spectrum appeared as a single peak at 2.0 ppm, with a complete absence of Cr and Cho peaks. As reported previously, 2.0 ppm resonance at long TE, with a lack of Cr and Cho peaks, is probably due to the N-acetyl compound of mucus glycoproteins¹⁰. However, mucus glycoproteins may be present in metastatic mucinous adenocarcinomas¹¹ and colloid-like cysts¹², as well as in brain tumors with high mucinous compounds^{13,14}, potentially mimicking N-acetyl compounds of mucocoele. Hence, caution should be taken interpreting a dominant peak at 2.0-ppm.

We apply short TE ¹H-MRS sampling to confirm the presence of an abnormal peak at 2.0 ppm, and the absence of mI, which is detectable only in short T2 relaxation time at 3.5-3.6 ppm. Notably, the spectrum of ¹H-MRS with short TE revealed an additional broad component at 3.8 ppm (Figure 3B), presumably due to a sialic compound of mucus glycoproteins, which has a shorter T2 relaxation time¹³. To our knowledge, this is the first description of *in vivo* ¹H-MRS demonstrating a dominant peak at 2.0 ppm at long TE and an additional component at 3.8 ppm at short TE due to the mucus glycoprotein compounds of mucocoele.

In conclusion, post-traumatic mucocoeles can occur several decades after initial trauma and may be clinically asymptomatic. The neuroradiological appearance of fronto-ethmoidal mucocoeles is quite variable, depending on their composition. The presence of residual post-traumatic changes may be challenging. A complex diagnostic workup includes standard pre- and post-contrast-enhanced MR imaging, but in addition, ¹H-MRS with 2.0 ppm peak at long TE and 3.8 ppm at short TE proved useful for characterizing lesions and avoiding potential diagnostic pitfalls.

References

- Kountakis SE, Senior B, Draf W. The Frontal Sinus. Berlin, Heidelberg, New York: Springer. 2005.
- Lee KC, Lee NH. Comparison of clinical characteristics between primary and secondary paranasal mucocoeles. *Yonsei Med J*. 2010; 51 (5): 735-739.
- Rosado P, de Vicente JC, Villalain L, et al. Posttraumatic frontal mucocoele. *J Craniofac Surg*. 2011; 22 (4): 1537-1539.
- Derham C, Bucur S, Russell J, et al. Frontal sinus mucocoele in association with fibrous dysplasia: review and report of two cases. *Childs Nerv Syst*. 2011; 27 (2): 327-331.
- Sakamoto H, Tanaka T, Kato N, et al. Frontal sinus mucocoele with intracranial extension associated with osteoma in the anterior cranial fossa. *Neurol Med Chir (Tokyo)*. 2011; 51 (8): 600-603.
- Lanzieri CF, Shah M, Krauss D, et al. Use of gadolinium-enhanced MR imaging for differentiating mucocoeles from neoplasms in the paranasal sinuses. *Radiology*. 1991; 178 (2): 425-428.
- Hernesniemi J, Ishii K, Niemela M, et al. Lateral supraorbital approach as an alternative to the classical pterional approach. *Acta Neurochir Suppl*. 2005; 94: 17-21.
- Peral Cagigal B, Barrientos Lezcano J, Floriano Blanco R, et al. Frontal sinus mucocoele with intracranial and intraorbital extension. *Med Oral Patol Oral Cir Bucal*. 2006; 11 (6): E527-E530.
- Kechagias E, Georgakoulis N, Ioakimidou C, et al. Giant intradural mucocoele in a patient with adult onset seizures. *Case Rep Neurol*. 2009; 1: 29-32.
- Andre E, Xu M, Yang D, et al. MR spectroscopy in sinus mucocoele: N-acetyl mimics of brain N-acetylaspartate. *Am J Neuroradiol*. 2006; 27 (10): 2210-2213.
- Liu X, Germin BI, Zhong J, et al. N-Acetyl peak in MR spectra of intracranial metastatic mucinous adenocarcinomas. *Magn Reson Imaging*. 2010; 28: 1390-1394.
- Periakaruppan A, Kesavadas C, Radhakrishnan VV, et al. Unique MR spectroscopic finding in colloid-like cyst. *Neuroradiology*. 2008; 50 (2): 137-144.
- Opstad KS, Griffiths JR, Bell BA, et al. Apparent T(2) relaxation times of lipid and macromolecules: A study of high-grade tumor spectra. *J Magn Reson Imaging*. 2008; 27 (1): 178-184.
- Candiota AP, Majós C, Bassols A, et al. Assignment of the 2.03 ppm resonance in *in vivo* ¹H MRS of human brain tumour cystic fluid: contribution of macromolecules. *MAGMA* 2004; 17 (1): 36-46.

Domenico Montanaro, MD
Unit of Neuroradiology
Fondazione CNR/Regione Toscana G. Monasterio
Via G. Moruzzi 1
54123 Pisa, Italy
Tel.: +390503152824
Fax: +390503153535
E-mail: domont@ftgm.it