IMAGING CASE STUDY OF THE MONTH

MAGNETIC RESONANCE IMAGING–AIDED NAVIGATION IN ENDOSCOPIC SINUS SURGERY OF A BONE-DESTRUCTIVE SPHENOCLINOID MUCOCELE

ROEE LANDSBERG, MD
ARI DEROKE, MD

YORAM SEGEV, MD
DAN M. FLISS, MD

TEL-AVIV, ISRAEL

INTRODUCTION

Image-guided endoscopic sinus surgery (ESS) has gained wide acceptance in recent years. Endoscopic sinus surgeons have found the 3-dimensional navigation systems to be very helpful, especially when the familiar anatomy is distorted by disease or by previous surgery. Most commonly, otolaryngologists use computed tomography (CT) as their database for image-guided surgery, because CT provides clear definition of bony walls that separate the nasal cavity and paranasal sinuses from vital structures such as the brain, eyes, and carotid artery. Interestingly, despite the important role that magnetic resonance imaging (MRI) plays in the diagnosis of inflammatory and neoplastic disease, ESS guided by MRI solely or complementary to CT has been only rarely mentioned in the literature.1,2

We hereby present a rare case of a bone-destructive mucocele involving the sphenoid sinus and pneumatized anterior clinoid process, causing pressure on the superior orbital fissure and the optic nerve and consequently diplopia and papilledema. The unique location and radiologic appearance of the lesion had led us to add MRI to the CT database for 3-dimensional image-guided ESS. This addition proved critical and facilitated the accurate approach to the lesion.

CASE REPORT

A 49-year-old man was referred with mild left eye pain and diplopia that began several days before his admission. Six years earlier, he had undergone excision of a sinonasal cavity and anterior skull base inverted papilloma by a combined anterior subcranial and facial degloving approach. There were no operative or postoperative complications, and frequent follow-ups during the following 6 years did not reveal tumor recurrence. Physical examination upon the patient’s current admission revealed diplopia and papilledema in the left eye. Nasal endoscopy showed postoperative anatomic changes in the site from which the turbinates and anterior ethmoid cells had been resected. A soft tissue mass composed of bulky polyps was noticed at the left posterior ethmoid area (Fig 1). A CT scan demonstrated primarily left-sided postoperative changes and opacification of the posterior ethmoid and sphenoid sinuses. There was complete bony erosion of the sphenoid sinus lateral wall, without any osseous border along the optic nerve canal and the superior orbital fissure (Fig 2A). For a better definition of the disease, an MRI scan was performed. This modality clearly showed that the mass consisted of 2 distinct components. The first was hyperintense on both T1- and T2-weighted images and did not enhance after gadolinium injection. It involved the sphenoid sinus and extended into the left

Fig 1. Soft tissue mass as seen in posterior ethmoid region on presentation.

From the Departments of Otolaryngology–Head and Neck and Skull Base Surgery (Landsberg, DeRowe, Fliss) and Radiology (Segev), Sourasky Medical Center, Sackler Faculty of Medicine, Tel-Aviv University, Tel-Aviv, Israel.

CORRESPONDENCE — Roee Landsberg, MD, Dept of Otolaryngology–Head and Neck and Skull Base Surgery, Sourasky Medical Center, 6, Weizman Str, Tel-Aviv, Israel.
Fig 2. Hyperintense nonenhancing lesion extends from sphenoid sinus into anterior clinoid process on left, causing bone destruction (single arrows). This proved to be mucocoele. Note normal appearance of nonpneumatized right anterior clinoid process (double arrows in A). Adjacent mass proved to be granulation tissue. Signs of previous surgery are seen in anterior ethmoid region. A) Axial computed tomographic image, bone window. B) Axial unenhanced T1-weighted magnetic resonance image. C) Coronal gadolinium-enhanced T1-weighted magnetic resonance image.

clinoid process. The second component was an enhancing soft tissue mass located anterior and medial to that lesion (Fig 2B,C). By combining the information obtained from CT and MRI, the diagnosis of a sphenoid-clinoid mucocoele destroying the bony wall of the optic canal could be made. This conclusion was based on the fact that the shape of the sphenoclinoid lesion was similar to an expanded clinoid process, and it was nonenhancing. The signal intensity of mucocoeles varies; hyperintensity on both T1 and T2 weighting indicates a high protein content. The fact that the contralateral clinoid process was not aerated was confusing at first, but variability of clinoid pneumatization was assumed and subsequently helped in our final diagnosis.

Assuming that there was some component of secondary infection, we administered intravenous ceftriaxone sodium. The patient was discharged after 4 days with complete resolution of the diplopia. However, several weeks later, the diplopia recurred. A new MRI scan showed a persistent mucocoele without signs of resolution. In addition, the disk of the left eye was persistently swollen on repeated examinations. At that point, operative intervention was recommended.

Although the lesion appeared to be endoscopically accessible, we strongly believed that using a 3-dimensional navigation system during surgery would provide the essential precision needed in this case. However, in contrast to a typical image-guided operation in which navigation is based upon CT, in this particular case the CT did not clearly demonstrate a distinct lesion, although MRI did. Therefore, we decided to use MRI as the major database for the navigation system. In our institute we use the Brainlab navigation system (Brainlab, Heimstetten, Germany) for cases of ESS in which pathological conditions obscure the usual anatomic landmarks. This system is based on infrared localization of the surgical instruments and includes an image fusion software module that allows co-registering of different diagnostic image sets such as CT and MRI. Similar to other navigation systems, this system can provide accuracy within 2 mm.
A week before surgery, an axial 1-mm-section CT scan was done for the navigated procedure according to the protocol indicated by the navigator manufacturer. In addition, an MRI study was done in which a gadolinium-enhanced coronal fast spin echo T1-weighted sequence was used for preoperative data acquisition. The image parameters for this sequence were repetition time, 660; echo time, 9.5; echo train length, 4; field of view, 24 × 18 cm; matrix, 256 × 192; number of excitations, 2; slice thickness, 3 mm with no gaps; and scan time, 3 minutes 21 seconds.

With the computer mouse, the circumference of the mucocele was marked in red repeatedly on each section. The optic nerve was marked in green in a similar manner. By means of the computer program, these MRI sections were overlapped with their matched CT sections. By combining the MRI and CT sections, we achieved a clear demonstration of the mucocele and the optic nerve. In addition, a “target sign” was marked on the inferomedial anterior face of the mucocele (Fig 3). This sign marked the point of expected surgical entry into the lesion.

The patient was registered with “Z-touch.” This is a laser product that allows the image-guided system to utilize the surface anatomy of the patient’s face to calculate an advanced surface-matching al-

**Fig 3.** Navigation image. Pink-colored mucocele as illustrated before operation on magnetic resonance image is overlapped with 3-dimensional computed tomogram. Rounded pink ball is the marked “target sign.” Edge of suction tube touches now-confirmed medial wall of mucocele, which is still intact. Note: right-left orientation is reversed in this image.

**Fig 4.** Edge of suction tube touches what is assumed to be medial wall of mucocele.

**Fig 5.** Mucocele is drained during incision of its medial wall with sickle knife.
Algorithm. Fiducials are not required. After attaching the reference star to the patient, the surgeon "Z-touches" the patient by "virtually" scanning the surface of the patient's face. Once this random scanning is complete, the patient is registered.

With a 4-mm 0° endoscope, a biopsy specimen was taken from the posterior ethmoid mass that later was reported as granulation tissue. Then, with the microdebrider, revision ethmoidectomy was accomplished. A sphenoid cavity was exposed just behind the mass. The lateral wall of this cavity was smooth, but it was essential to verify that this smooth wall was the medial wall of the mucocele, and not a more lateral structure in the vicinity of the optic canal (Fig 4). At that point, the CT-MRI overlapping view verified that the lateral smooth wall was the medial wall of the mucocele (Fig 3). With a sickle knife, a horizontal incision was made at the wall of the mucocele, and a thick, mucoid, whitish material was aspirated (Fig 5). The medial wall of the mucocele was removed, and a wide exposure of the lesion was achieved (Fig 6). The extension of the mucocele into the pneumatized anterior clinoid process could be clearly visualized (Fig 7). One year after the surgery, the patient feels well and has no diplopia. Physical examination shows that the nasal and ethmoid cavities are free of disease; the sphenoid sinus and the pneumatized clinoid process are wide open and contain no mucocele. The papilledema resolved.

**DISCUSSION**

In the vast majority of cases, ESS aims to remove or drain an inflammatory disease process that is confined to the bony framework of the nose and sinuses. Because of the intimate proximity of the nose and sinuses to vital structures such as the eyes, brain, and internal carotid artery, it is always a challenge to remove the disease process without causing major complications such as blindness, a cerebrospinal fluid leak, or carotid artery bleeding. The CT scan provides clear definition of the delicate bony framework that separates the nose and sinuses from these vital...
structures and therefore has gained popularity among otolaryngologists as the major imaging modality for image-guided ESS. As long as the surgical instruments are viewed within the bony framework, the surgeon knows that he or she is working in a relatively safe surgical field.

In contrast to otolaryngologists, neurosurgeons typically prefer MRI for image-guided surgery. Unlike the sinonasal cavity, the brain contains various soft tissue structures without any bone partitions among them. It is, therefore, critical for the neurosurgeon to be able to identify a lesion adjacent to normal brain tissue. In these circumstances, MRI is usually superior to CT.

The otolaryngology literature contains a large number of publications reviewing CT-guided ESS. Magnetic resonance imaging-guided ESS has been described as a usable option or as an intraoperative imaging guide for noncomplex cases such as chronic sinusitis or polyposis. We believe that for the vast majority of ESS cases in which navigation is required, CT is indeed the preferred imaging tool. However, the current case shows that in certain circumstances MRI may play an important role in image-guided ESS.

Although extremely rare, sphenoid and even anterior clinoid mucoceles that compromise eye function have been described. A mucocele associated with neoplasia has also been mentioned. The current case was challenging because of the lack of anatomic landmarks after the previous surgery and because of the difficulty in distinguishing the targeted lesion from the adjacent soft tissue. The CT provided critical information regarding the extent of bone destruction. However, only MRI clearly demonstrated the borders of the mucocele and hence enabled us to perform the planned precise marsupialization.

The navigation system required extra time for the registration process, tool adjustment, tool calibration, and software operation. Still, its contribution to the safety of the operation at the critical moments was invaluable and therefore outweighs the time factor.

We speculate that whenever there is significant disruption of bony integrity between the sinonasal cavity and the eye or the brain, MRI-based guidance in ESS should be considered.

CONCLUSIONS

This case exemplifies the fact that when the bony framework of the nose and sinuses is injured or when precise localization of a soft tissue lesion is warranted, MRI may be an essential modality for image-guided ESS.

REFERENCES
