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Magnetic Resonance Imaging-Guided Fine Needle Aspiration for the Diagnosis of Skull Base Lesions

Abstract—Magnetic resonance imaging (MRI)-guided fine needle aspiration was used to obtain tissue from lesions of the skull base for cytologic diagnoses in 14 patients. Our technique utilized a guiding system to enable three-dimensional orientation in a two-dimensional scan and a high nickel content 22 gauge needle to minimize significantly MRI artifact. Needle access to the skull base was provided through a subzygomatic or retromandibular approach. In seven of nine cases an accurate diagnosis was established by this technique and later confirmed by surgical exploration and histologic analysis. Failure to obtain a representative specimen from the lesion occurred in one case and difficulty in interpreting the cytologic features of the tissue was encountered in another case. The indications, limitations, and technical details of the procedure are described. (*Skull Base Surgery, Volume 2, Number 3, 1992, p. 167*)

Contemporary radiologic imaging techniques have produced accurate identification and localization of lesions of the skull base. A presumptive diagnosis can often be based on the radiologic features and the location of the lesion. To achieve a histopathologic diagnosis, a major skull base procedure is usually needed to gain access to the lesion and consequently is performed only with definitive resection. Fine needle aspiration (FNA) has been proven as a valuable diagnostic technique for lesions of the head and neck.[1,2] The application of this procedure to the pathology of the skull base has been limited primarily because of the difficulty in accurately reaching the site of disease and the potential for injuring adjacent vital structures. FNA can be performed under radiologic guidance to safely and selectively obtain cytologic material from many anatomic sites.[3,4] Prior attempts with computed tomographic (CT) guided FNA were limited by low contrast resolution, beam hardening artifacts from the dense bone of the skull base, and scans limited to the axial plane. With the use of magnetic resonance imaging (MRI) these limitations have been overcome and the technique of FNA has been applied to the skull base.

MATERIALS AND METHODS

Over the past 4 years, FNA under MRI guidance was performed for cytologic diagnosis of skull base lesions in 14 patients (Table 1). These individuals had lesions that were not palpable for conventional FNA and were inaccessible by endoscopic biopsy.

MRI scans were performed on a 0.3 Tesla permanent magnet system (FONAR B-3000, Melville, NY). With one signal excitation 256 × 256 matrix, two-dimensional Fourier transform images were obtained. A 25.6 cm field of view yielded 1 × 1 mm pixels, and 3.5 mm thick images were obtained. Standard spin-echo sequences were employed with an echo time (TE) varying from 14 to 28 msec repetition and a (TR) varying from 267 to 100 msec. Field echo sequences were obtained with a flip angle of 10°

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Table 1. Cases of Skull Base Lesions Analyzed with MRI Guided FNA*

Case†	Approach	Site of Lesion	FNA	Histopathology
1	Subzygomatic	Pterygoid space	Squamous cell carcinoma	N/A
2	Retromandibular	Jugular foramen	Adenoid cystic	Adenoid cystic
3	Subzygomatic	Foramen ovale	Squamous cell carcinoma	Squamous cell carcinoma
4	Retromandibular	Jugular foramen	Paraganglioma	Negative
5	Subzygomatic	Infratemporal fossa	Mucoepidermoid	N/A
6	Retromandibular	Jugular foramen	Paraganglioma	N/A
7	Retromandibular	Foramen rotundum	Neural tissue	Neurofibroma
8	Subzygomatic	Cavernous sinus	Granuloma	Granuloma
9	Retromandibular	Jugular foramen	Paraganglioma	Paraganglioma
10	Subzygomatic	Foramen ovale	Inflammatory	N/A
11	Subzygomatic	Infratemporal fossa	Inflammatory	N/A
12	Subzygomatic	Infratemporal fossa	Malignant schwannoma	Malignant schwannoma
13	Subzygomatic	Clivus	Chordoma	Lymphoepithelial cancer
14	Subzygomatic	Infratemporal fossa	Mucoepidermoid	N/A

*FNA; fine needle aspiration; MRI: magnetic resonance imaging; N/A: not available.
†Cases 1, 5, 10, 11, and 14 did not receive a surgical procedure and consequently there was no histopathologic specimen. In case 4 surgical exploration failed to reveal a lesion.

to 90°, a TE of 10 to 20 msec, and a TR of 173 to 500 msec. A V-shaped surface marker consisting of two tuberculin syringe barrels welded together at a 30° angle was specially designed for MRI-guided FNA. The syringe barrels were filled with mineral oil, which was easily identified on a MRI scan. The V-shaped surface marker facilitated the orientation of the surface anatomy with the deeper structures including the lesion. On MRI, the surface marker appeared as two bright densities overlying the surface of the skin (Fig. 1A). On a scan through the center of the lesion, the distance between these two densities was measured. An extrapolation back to the surface marker was then performed by calculating the distance between the limbs of the V. In this way the position of the lesion relative to the surface marker could be approximated. Local anesthesia of the approximate site for FNA was achieved in most patients by local infiltration with 1% lidocaine (Xylocaine) with 1:100,000 epinephrine. A 22 gauge 5 inch needle containing five times the nickel of standard aspiration cytology needles was used for the FNA.[5] The increased nickel content reduced the ferromagnetic properties to minimize scan distortion significantly. An MRI field echo scout view (requiring approximately 30 to 60 seconds of scan time) was used to estimate the best position for needle insertion, the angle of needle direction, and the depth of penetration to reach the suspected lesion. Following initial placement of the biopsy needle, a second field echo scout view was obtained at an

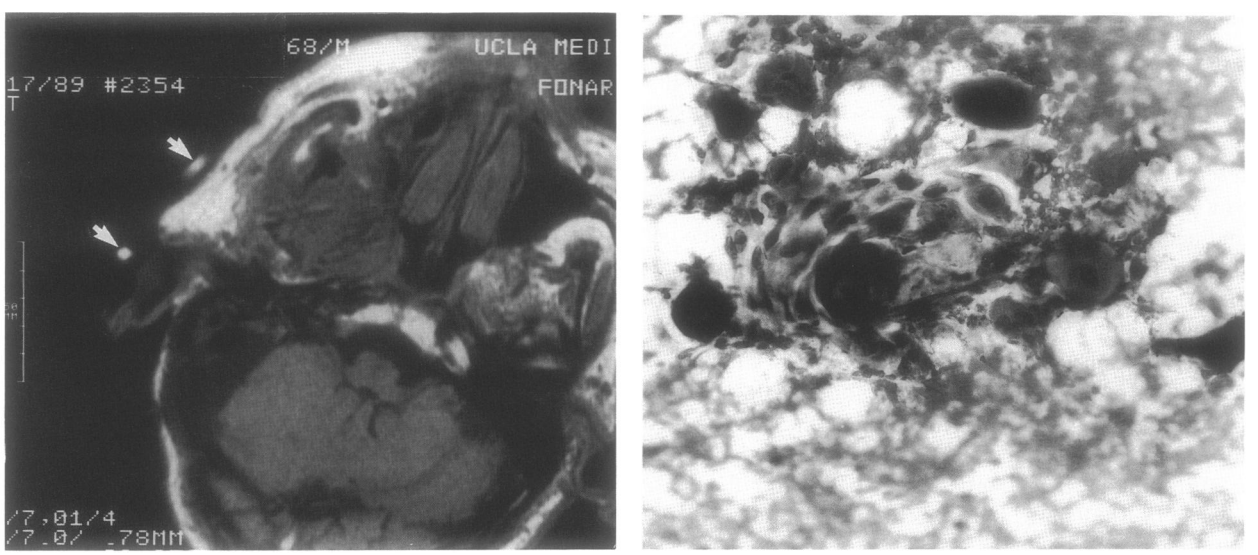


Figure 1. A: Axial field echo scout view image from the patient in case 5 demonstrating a mass filling the right infratemporal fossa. The two bright densities on the skin surface (arrows) are from the V-shaped surface marker. TR 500 msec, TE 20 msec, 2 NEX, head coil. B: Medium power view of the cytologic aspirate revealing a high grade mucoepidermoid carcinoma. Note the focal keratinization (center) and prominent nuclear anaplasia. (Papanicolaou's stain; ×300).

oblique angle through the needle. Accurate assessment of the position of the needle tip was ascertained by two scans through the axis of the needle.

Either a surface or head coil was used in each case to enhance imaging of the desired region. By positioning the needle at an angle, interference with either the surface or head coil was avoided.

Once the needle tip position had been determined, the needle's hub was attached to a gun-type syringe. FNA was then performed in a standard manner. The aspiration material obtained was smeared on glass slides, dried, and stained with May-Grünwald-Giemsa or Papanicolaou stains. Representative slides were immediately examined to ensure that the biopsied material was adequate for cytologic diagnosis. The entire procedure required between 30 to 60 minutes to complete.

NEEDLE APPROACHES

Several different needle biopsy approaches were chosen, depending on the location of the lesion.[6] Access to the infratemporal fossa, clivus, foramen ovale, and cavernous sinus regions was obtained through a subzygomatic approach. The V-shaped surface marker was placed with the apex directed superiorly and centered over the zygomatic arch. The needle was inserted below the arch and through the region of the mandibular notch. The working field could be greatly increased by having the patients open their mouths.

The jugular foramen and foramen rotundum were accessed through a retromandibular approach. With this method, the V-shaped surface marker was placed with its apex directed superiorly and centered over the region of the mastoid tip. The needle was inserted just posterior to the angle of the mandible and directed in a cranial and rostral direction.

RESULTS

Pathologic material for cytology was obtained in all 14 patients in this study. Nine patients subsequently had a surgical procedure to either excise or biopsy the lesion in question. In five patients an operation was not performed. For those patients who had an operative intervention, a comparison was made between the preoperative cytologic and the postsurgical histopathologic diagnosis of the lesion. The diagnoses were in agreement in seven cases (78%). Disparity between the histopathologic and the cytologic results occurred in two cases. This discord was considered to be secondary to failure in obtaining an adequate specimen in one case (case 4) and difficulty in interpreting the aspirate in another case (case 13). The patient in case 4 had a vagal paralysis on presentation with MRI evidence of a small jugular foramen lesion extending distal to the skull base. Although the FNA contained cells consistent with a paraganglioma, surgical exploration failed to demonstrate a lesion. In case 13, the cytologic aspirate of a clivus lymphoepithelial carcinoma was misinterpreted as representing a chordoma. No complications were encountered in this series of radiologically guided FNA.

ILLUSTRATIVE CASE REPORTS

Case 5

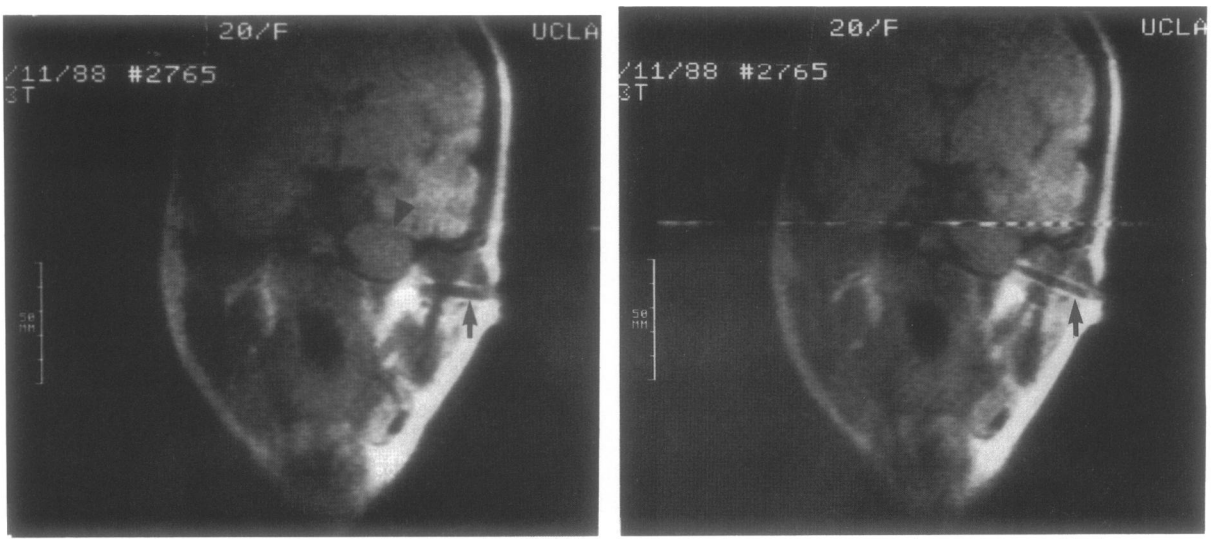
A 68-year-old man noted progressive right facial pain over 2½ years. Six months prior to his presentation, he developed blurred vision. An MRI scan demonstrated a mass in the right pterygomaxillary fossa with extension to the orbital apex and infratemporal fossa. An MRI-directed FNA was performed via a subzygomatic approach and the cytologic study revealed a mucoepidermoid carcinoma (Fig 1). Medical problems prohibited surgery and radiation therapy was deemed the best therapeutic option for this patient.

Case 7

A 20-year-old woman was referred to the University of California, Los Angeles Medical Center with a chronic left-sided hearing loss and recent onset of double vision. On physical examination, she was noted to have diplopia on left lateral gaze and a serous otitis media. CT scan revealed a 2½ cm diameter tumor extending through the skull base in the region of the foramina rotundum and ovale. An MRI-guided FNA via a retromandibular approach was utilized to obtain material from this lesion (Fig. 2). Cytologic examination of the specimen showed spindle cells consistent with a neuroma. The tumor was excised through a left frontotemporal approach and histopathologic examination of the excised tissue confirmed a benign nerve sheath tumor.

DISCUSSION

MRI-guided FNA represents a significant merger of advancements in the fields of radiology and pathology to diagnose lesions previously considered inaccessible by any means other than an open surgical procedure. MRI-guided FNA has required considerably greater refinement than just the simple combination of technologies. The development of a high nickel content needle has significantly improved the ability to reduce artifacts deriving from metal alloy in the MRI scanning field. With this device, assessment of the relationship of the needle tip to the suspected site of the lesion as well as to normal vital structures can be accurately ascertained. The use of a



A B

Figure 2. A: Coronal T_1-weighted image from the patient in case 7 demonstrating a homogenous soft tissue mass (arrowhead) below the left temporal lobe. Note the initial incorrect position of the needle (arrow). TR 500 msec, TE 20 msec, 2 NEX, surface coil. B: Follow-up image after correct needle placement. Note that the needle is now entering the lesion (arrow). TR 500 msec, TE 20 msec, 2 NEX, surface coil.

V-shaped surface marker is of great benefit in determining the surface relationship, depth, and necessary angle of approach needed to access deep skull base lesions. Continued experience with this advice allows more accurate initial attempts at needle placement.

Through the different methods that were employed, we did not encounter any lesions of the skull base that were considered inaccessible by MRI-guided FNA. The subzygomatic approach provides good access to the pterygoid space, infratemporal fossa, foramina ovale and rotundum, and the region of the clivus. The jugular foramen, deep lobe of the parotid, and masticator space are readily accessed through a retromandibular approach.

Although we have not encountered complications with MRI-guided FNA, theoretically neurovascular or organ injury could occur. The thin gauge of the needle should allow for minimal vessel trauma and it would be expected that puncture of any large vessels would spontaneously close. Additionally, major vessels can be identified on an MRI scan and a needle approach that will avoid these structures can be used. Nerve injury secondary to needle impalement might result in at least temporary loss of function. Avoidance of the region of the facial nerve trunk, optic nerve, eye and brain should limit accidental damage to these structures. With the use of the V-shaped surface marker and MRI field echo scout views, orientation between the aspiration needle and these organs can be accomplished.

Interpreting the cytologic specimen from FNA of the skull base continues to be an evolving technique. The cytologic features of many of the diseases and tumors of the skull base have not been adequately addressed to date and consequently much of this information and experience remains new.

Our work with MRI-guided FNA of the skull base should be viewed as preliminary. Although we are optimistic that this technique can provide safe and accurate diagnoses, further experience approaching these lesions and interpreting the pathologic results from cytology is needed.

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