

Magnetic resonance imaging in acute mastoiditis

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Abstract

Background: In cases of suspected mastoiditis, imaging is used to evaluate the extent of mastoid destruction and possible complications. The role of magnetic resonance imaging (MRI) in mastoiditis has not been systematically evaluated.

Purpose: To assess the diagnostic performance of MRI in patients with suspected acute mastoiditis.

Material and Methods: Twenty-three patients with suspected acute mastoiditis were included in this retrospective study (15 boys, 8 girls; mean age, 2 years 11 months). All patients were examined on a 1.5 T MRI system. The MRI examination included both enhanced and non-enhanced turbo spin echo (TSE), diffusion-weighted images, and venous time-of-flight magnetic resonance angiography (TOF MRA) for the evaluation of the venous sinuses. Surgical findings, as well as clinical and imaging follow-up were used as the standard of reference. The sensitivity and accuracy of MRI for mastoiditis and subperiosteal abscesses was calculated.

Results: Twenty (87%) of 23 patients had mastoiditis, and 12 (52%) of 23 patients had a subperiosteal abscess in addition to mastoiditis. Mastoiditis and subperiosteal abscesses were identified by MRI in all cases. Sensitivity for mastoiditis was 100%, specificity was 66%, and accuracy was 86%. Sensitivity for subperiosteal abscesses was 100% and accuracy was 100%.

Conclusion: Multiparametric MRI has high accuracy for mastoiditis and subperiosteal abscesses.

Keywords

Mastoiditis, infection, magnetic resonance imaging (MRI), children

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Introduction

Mastoiditis is usually caused by acute otitis media spreading from the ear to the mastoid. Its incidence has greatly decreased since the introduction of antibiotics (1), but it still presents a significant health problem because it may lead to potentially fatal complication (2). While initial diagnosis of acute mastoiditis is mostly based on clinical findings, computed tomography (CT) is often used to assess the extent of mastoiditis (3). Magnetic resonance imaging (MRI) has an excellent soft tissue contrast and appears well suited to evaluate both the mastoid and possible complications of mastoiditis. The aim of this study was to assess the accuracy of MRI in patients with suspected mastoiditis.

Material and Methods

This retrospective study was approved by the local ethics committee and written informed consent was waived. The radiology information system (RIS) of

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our hospital was searched for patients who were referred for MRI with suspected mastoiditis between April 2008 and December 2012. Twenty-three patients with suspected mastoiditis were identified and included in the study (15 boys, 8 girls; age range, 8 months to 12 years 11 months; mean age, 2 years 11 months). Symptoms included postauricular swelling ($n=21$), postauricular erythema ($n=17$), protrusion of the auricle ($n=19$), otorrhoea ($n=8$), fever ($n=13$), and otalgia ($n=19$). There were no cases with facial nerve symptoms. The time interval between the beginning of symptoms and the MR examination was in the range of 1–21 days (median, 3 days). Ten patients also had a history of previous otitis media.

MRI

All patients were examined on a 1.5T MRI system (Magnetom Avanto, Siemens Medical Solutions, Erlangen, Germany). MRI was performed on the day of admission to the hospital. The patients were examined in the supine position. The system's standard 8-channel head coil was used for signal acquisition. Transverse dual echo turbo spin echo (TSE) images of the brain and skull base were acquired with: repetition time/first echo time/second echo time, 5890/11/190 ms; field of view (FOV), 162 × 200 mm; matrix, 416 × 512; slices, 26; and slice thickness, 4 mm. Acquisition time for the dual echo sequence was 4 min 12 s. Transverse T1-weighted (T1W) images of the skull base were acquired with: repetition time/echo time, 500/8.6 ms; FOV, 165 × 230 mm; matrix, 368 × 512; slices, 17; slice thickness, 2 mm. Acquisition time was 4 min 36 s. Transverse diffusion-weighted echoplanar images (DWI) of the skull base were acquired with: repetition time/echo time, 3000/88 ms; FOV, 230 × 230 mm; matrix, 128 × 128 mm; slices, 19; and slice thickness, 2 mm. Acquisition time was 1 min 23 s. DWIs were acquired with b-values of 0, 500, and 1000. Coronal time-of-flight images of the brain and skull base were acquired with: repetition time/echo time, 30/6.5 ms; FOV, 158 × 230 mm; matrix, 176 × 256; slices, 70; and slice thickness, 2 mm. Acquisition time was 4 min 21 s.

0.1 mL/kg body weight Gadovist® (Gadobutrol, Bayer Schering Pharma, Berlin, Germany) were applied intravenously before the acquisition of contrast-enhanced images, followed by 10 mL saline.

Transverse contrast-enhanced T1W TSE images of the skull base with fat saturation were acquired with: repetition time/echo time, 582/8.6 ms; FOV, 165 × 230 mm; matrix, 368 × 512; slices, 17; and slice thickness, 2 mm. Acquisition time was 3 min 34 s. Coronal contrast-enhanced T1W TSE images of the skull base and brain with fat saturation were acquired with: repetition time/echo time, 718/8.6 ms; FOV,

157 × 210 mm; matrix, 384 × 512; slices, 21; and slice thickness, 2 mm. Acquisition time was 6 min 13 s.

Total acquisition time was 24 min.

Twenty patients were examined under general anesthesia, two patients under sedation, and one patient without medication.

Image evaluation and standard of reference

Image evaluation was performed independently by two board-certified radiologists (with 9 and 11 years of experience with head and neck MRI, respectively). In cases of differing findings, the final decision was met in consensus. Fluid accumulations, increased contrast enhancement of the mastoid, and restricted diffusion in the mastoid were interpreted as signs of mastoiditis. Imaging findings were interpreted as mastoiditis when two or more of the criteria mentioned above were met. Subperiosteal fluid collections, extracranial contrast enhancement adjacent to the mastoid, and extracranial restricted diffusion adjacent to the mastoid were interpreted as a sign of a subperiosteal abscess. Imaging findings were regarded as positive for subperiosteal abscess when two of the three criteria were met.

Surgery findings were used as the standard of reference. Twenty-one (91%) of 23 patients were treated by mastoidectomy. Paracentesis with insertion of grommets was performed in 22 (96%) of 23 patients. Bilateral paracentesis with insertion of grommets was performed in 17 (82%) of 23 patients, while five (22%) of 23 patients had unilateral paracentesis with insertion of grommets. Adenotomy was performed in 21 (91%) of 23 patients. Two (9%) of 23 patients received antibiotic therapy without mastoidectomy and one of these patients also underwent mastoid biopsy. MR follow-up was available in eight (35%) of 23 patients, including the two patients who did not receive mastoidectomy. MRI follow-up was performed during the first month after the initial MRI examination.

Statistical analysis

The sensitivity and accuracy of MRI for mastoiditis and subperiosteal abscesses was calculated based on the standard of reference described above. Data were analyzed using MedCalc 12.0 (MedCalc Software, Ostend, Belgium).

Results

Based on the standard of reference, mastoiditis was confirmed in 20 (87%) of 23 patients (Fig. 1), and a consecutive subperiosteal abscess was identified in 12 (52%) of 23 patients. The left mastoid was affected in 12 (52%) of 23 patients and the right mastoid in eight

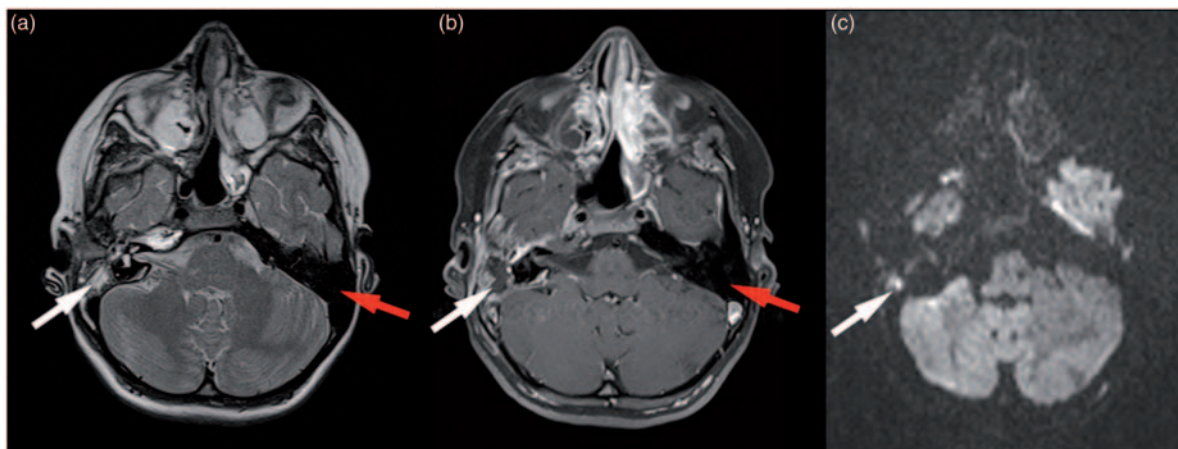


Fig. 1. An 11-year-old boy with right-sided mastoiditis. (a) T2W image in axial orientation; (b) axial T1W contrast-enhanced image with fat saturation; (c) DWI ($b = 1000$). A fluid accumulation with peripheral contrast enhancement and restricted diffusion is seen in the right mastoid (white arrow). In contrast, the normal left mastoid is air-filled (red arrow).



Fig. 2. A 2-year-old girl with right-sided mastoiditis and venous sinus thrombosis. (a) Axial T1W contrast-enhanced image; (b) coronal T1W image; (c) coronal time-of-flight venography image. Fluid accumulation and increased contrast uptake in the right mastoid (red arrow). Thrombus in the right transverse sinus (white arrow).

(35%) of 23 patients. The remaining three patients included one case of cholesteatoma, one with otitis media, and one with a solid mass of the mastoid, which was proven to be a manifestation of acute lymphatic leukemia by mastoid biopsy.

MRI identified one case of thrombosis of the transverse and sigmoid sinus (Fig. 2), which was confirmed by surgical findings. Furthermore, MRI detected an infratentorial epidural abscess (Fig. 3) in two patients, which was also confirmed by surgery.

Sensitivity for mastoiditis was 100%, specificity 66%, and accuracy was 86%. Both readers agreed regarding the presence or absence of mastoiditis in 22 (96%) of 23 cases and had differing results in one case ($\kappa = 0.78$). Sensitivity for subperiosteal abscesses was 100% and accuracy 100%. All (12 of 12, 100%) subperiosteal abscesses were identified by both readers ($\kappa = 1$).

Discussion

The results of the current study show that MRI has excellent accuracy for mastoiditis and concurrent subperiosteal abscesses. It also demonstrates the potential of MRI for assessing mastoiditis complications. To our knowledge, no systematic evaluation of the accuracy of MR in suspected mastoiditis has been published previously.

At first sight, our findings differ greatly from earlier works, which investigated the use of incidental MR findings for diagnosing mastoiditis. Polat et al. (4) and Meredith et al. (5) found that fluid signal intensity in the mastoid should not be interpreted as a sign of mastoiditis. Based on our own clinical experience we fully agree that fluid retention in the mastoid is a common incidental finding of little clinical consequence, if signs of inflammation are otherwise absent.

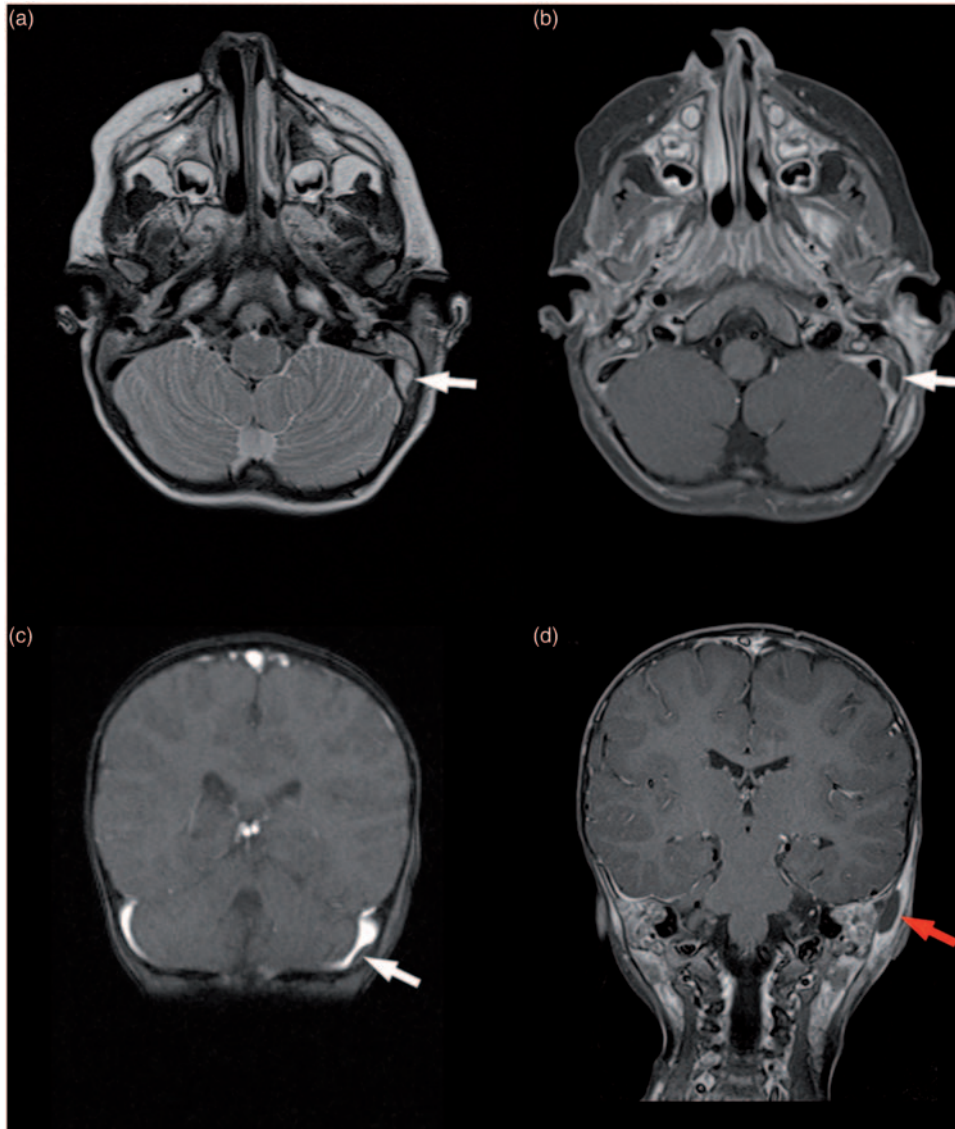


Fig. 3. A 1-year-old boy with left-sided mastoiditis. A perisinus abscess (white arrow) is seen in (a) axial T2W and (b) axial T1W, contrast-enhanced fat saturation. The phase contrast angiography (c) demonstrates the compression of the sigmoid sinus caused by the perisinus abscess. The coronal contrast-enhanced T1W image (d) demonstrates a subperiosteal abscess in the same patient (red arrow).

However, Polat et al. and Meredith et al. only evaluated the role of T2-weighted (T2W) images, while the role of DWI or contrast-enhanced MRI is not mentioned. In contrast, our results are based on multiparametric evaluation, as T2W, T1W images with without contrast enhancement, and DWI were used. Our choice of imaging protocol is influenced by previous studies, which has demonstrated the usefulness of both DWI (6) and contrast media (7–9) for diagnosing pyogenic infection. While gadobutrol is approved for use in adults and children aged 2 years and older, we used gadobutrol for all patients included in the study, including 13 patients younger than 2 years, because of the potentially life-threatening nature of possible intracranial

complications of mastoiditis and because of previous experience with contrast agents in infectious disease.

The studies by Polat et al. and Meredith et al. also completely differ from our study in regard to inclusion criteria. These studies retrospectively evaluated patients who received MRI of the skull and the skull base, regardless of symptoms. On the other hand, only patients with clinically suspected mastoiditis were included in our study.

The current study shows a rather low specificity of MRI for acute mastoiditis (66%). The specificity of MRI is limited by the fact that fluid collections in the mastoid cells are not necessarily pathological and that contrast enhancement of the mucosal lining of mastoid

cell may be caused by hyperemia due to otitis media, even if the mastoid is not infected. However, the estimate of specificity is based on just three patients who did not have mastoiditis. The assessment of specificity is limited by the preselection of patients based on clinical criteria, as most patients without clinical signs of mastoiditis do not receive an MRI scan. A larger sample would be needed for more accurate assessment of specificity.

While CT is often used for imaging suspected mastoiditis, a comprehensive evaluation of the accuracy of CT in mastoiditis is lacking. Antonelli et al. have shown that CT is able to distinguish between coalescent and non-coalescent mastoiditis with high sensitivity and specificity (3). In this case the reported sensitivity was lower in comparison with our study (67% vs. 100%), while the specificity was higher (90% vs. 67%). These differences may be caused by differing inclusion criteria used in the studies. While only patients with acute mastoiditis were enrolled in our study, Antonelli et al. also included patients with suspected chronic mastoiditis. Migirov et al. showed that CT has a high sensitivity for subperiosteal abscesses (96%), similar to our results (10).

Pediatric MRI, including MRI of the mastoid, has three important disadvantages in comparison to CT: longer scan times, more limited availability, and the eventual need for general anesthesia. While the logistical challenges presented by pediatric emergency MRI are considerable, MRI in suspected mastoiditis also has considerable potential advantages. Besides the high accuracy demonstrated in the current study, these also include absence of radiation exposure and better sensitivity for the detection of brain abscesses in comparison to CT (11).

The current study has several limitations. Above all, no comparison with CT, which is routinely used for imaging in cases of suspected mastoiditis by many centers, is available. In MRI, the diagnosis of mastoiditis is based on signs of pyogenic infection and thus coalescent mastoiditis, i.e. a fluid collection, restricted diffusion, and surrounding contrast enhancement. However, MRI is not suited for evaluation of small bony structures like the mastoid septa, whose destruction is an important sign of mastoiditis on CT. This may be a disadvantage of MRI in less pronounced cases of mastoiditis.

The use of an echo-planar sequence for DWI can also be considered a limitation. Several authors recommend the use of turbo spin echo diffusion-weighted sequences instead of echo-planar sequences for evaluation of the mastoid because they show fewer susceptibility artifacts (12,13).

One patient did not receive surgical treatment or biopsy and thus no surgical proof for the presence or absence of mastoiditis was available. In this case,

diagnosis was based on clinical and imaging follow-up, which is however presumed to be less reliable than surgical findings.

The frequency of intracranial complications observed in the current study is low, and because of the relatively low overall number of patients the study is not suited for a conclusive evaluation of such complications.

In conclusion, multiparametric MRI has high sensitivity and diagnostic accuracy in suspected mastoiditis. Comparison with CT is needed to decide if MRI can replace CT as the primary method for mastoiditis imaging.

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