

97. Overview of MR Contrast Agents

Gadolinium chelates serve in MRI as intravenous contrast media, much like the role of iodinated agents in CT. Those with a purely extracellular distribution and renal excretion are the most commonly employed. Gadolinium is a heavy metal, extremely toxic in its elemental form. The safety basis of gadolinium-based contrast agents thus lies in the ability of a chelate to tightly bind the gadolinium ion, ensuring rapid, near complete excretion (see Chapter 98). The paramagnetic effect of the gadolinium ion reduces the T1 and T2 of nearby mobile protons, changes manifest as increased and decreased SI on T1 and T2WI, respectively. The latter effect—attributable to susceptibility or T2* effects—is used in first-pass perfusion imaging, but effects on tissue T1 are more commonly exploited clinically. In the CNS, blood brain barrier disruption allows passage of the extracellular chelate into pathologic tissue, resulting in lesion enhancement on T1WI, improving detection and lesion characterization. Illustrated in Figure 97.1 is a lung cancer metastasis to the brain on (A)

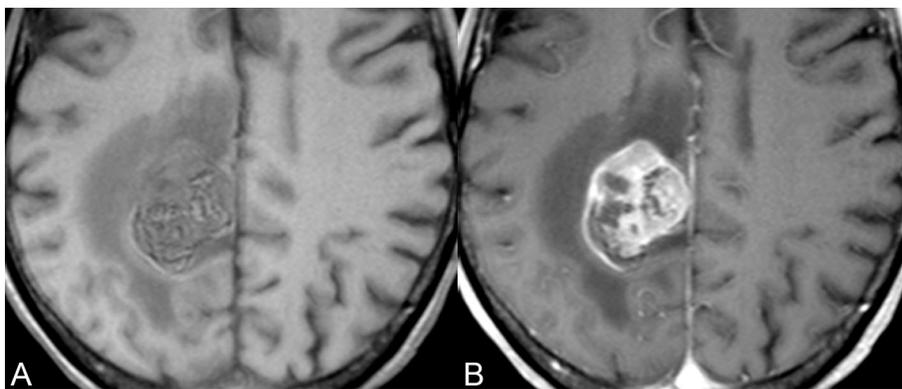


Fig. 97.1

pre- and (B) post-contrast T1WI, with enhancement improving both conspicuity and definition of the lesion margin in this instance. On post-contrast images, vascular tissues/structures such as the choroid plexus and nasal turbinates normally enhance, allowing ready identification of post-contrast scans. Similar principles allow depiction of vascular anatomy with CE MRA, as discussed in Chapters 99-101. Contrast enhancement, and thus improved lesion detection and characterization, in other regions of the body is reliant on metal chelate passage through leaky capillaries of granulation tissue or neoplastic lesions. The latter mechanism is demonstrated in Figure 97.2 where the conspicuity of a squamous cell carcinoma metastasis is markedly improved from that on (A) pre-contrast T1WI with (B) FS CE T1WI. Talar and calcaneal enhancement in Figure 97.2 B illustrates the importance of utilizing fat suppression to aid in visualization of enhancing osseous

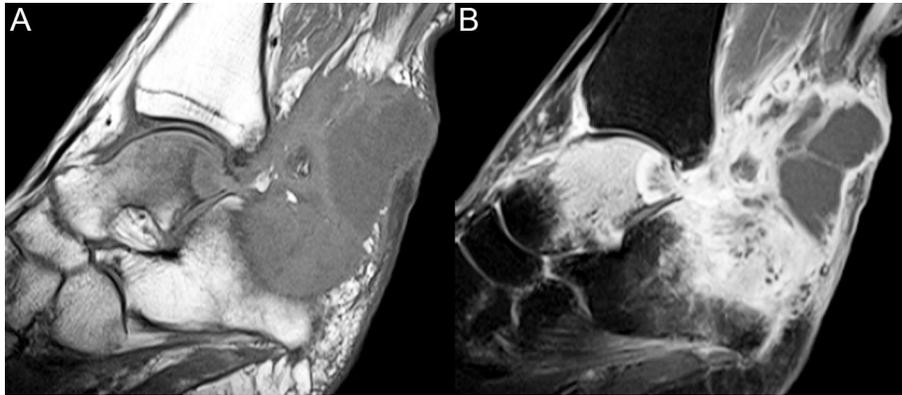


Fig. 97.2

pathology, a point further emphasized in Figure 97.3. Here, (A) sagittal T1WI demonstrates replacement of the normal high SI fatty marrow of T12 and L1 with metastatic tumor. Since subtle enhancing lesions are difficult to detect against high SI marrow on CE T1WI, spectral fat suppression is used for post-contrast imaging to null the normal hyperintense signal of fatty bone marrow. This is illustrated in the (B) FS CE T1WI of Figure 97.3 in

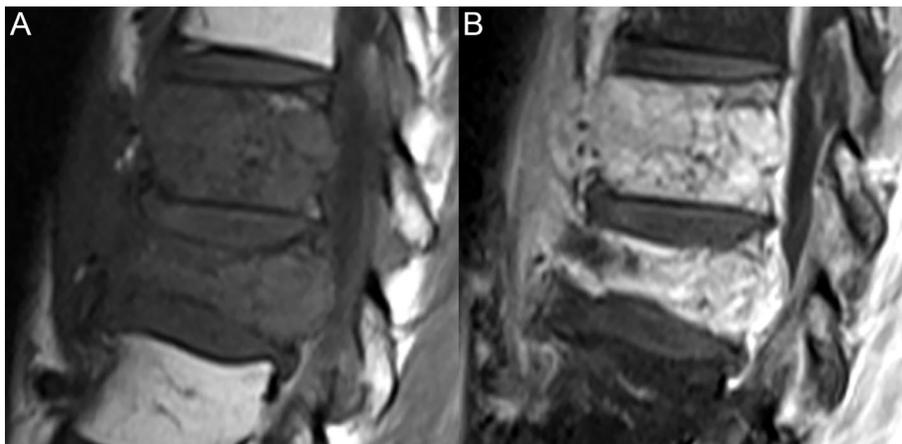


Fig. 97.3

which the T12 and L1 vertebral bodies prominently enhance compared to the suppressed SI of the other visualized vertebrae. A different approach, STIR, can also be used for fat suppression. However, STIR does not play a role in the detection of contrast enhancement, since the SI from all tissues with a short T1 is suppressed, including both fat and enhancing tissue. The approved purely renally excreted, extracellular gadolinium chelates all have similar efficacy—as assessed by T1 relaxivity. Two agents, MultiHance and Eovist (Primovist) have greater T1 relaxivity, and thus a greater effect with equivalent doses, due to transient protein binding. Large proteins like albumin tumble or spin at a slower rate than gadolinium chelates. The benzyloxymethyl group (see Figure 98.1) of both hepatobiliary

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agents (MultiHance and Eovist), however, allows transient interactions with albumin and other proteins, reducing the tumbling rate of the chelate. This reduced rate allows more efficient interactions with bulk water, further increasing T1 relaxivity.

Although the T1 relaxivity for all of the gadolinium chelates is lower at 3 T as compared to 1.5 T, lesion enhancement is improved at 3 T. This is due largely to the prolongation in tissue T1 that occurs with increasing field strength.

With the exception of MultiHance and Eovist (Primovist), both of which are used for delayed (hepatobiliary) phase liver imaging, the gadolinium chelates are excreted solely by the kidneys. The partial hepatobiliary excretion of the two agents just noted allows acquisition of delayed images in which there is enhancement of the normal liver parenchyma due to hepatocellular uptake. Detection of metastases and intrinsic pathologies associated with poorly functioning hepatocytes is facilitated by the hypointensity of these entities against the enhancing background (see Chapter 66).

Oral contrast agents are rarely used in MR. Substances high in fat or manganese (i.e. milk and blueberry juice) provide high SI contrast on T1WI, whereas iron-containing preparations can be used to provide low luminal SI on T1 and T2WI. Barium may also be used, but is a poor agent for MR, leading to low and high luminal SI on T1 and T2WI, respectively.