MR Imaging in Acute Multiple Sclerosis: Ringlike Appearance in Plaques Suggesting the Presence of Paramagnetic Free Radicals

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Summary: MR studies in three patients with multiple sclerosis have shown clearly defined rings within plaques of demyelination, having signal characteristics consistent with the presence of paramagnetic material. It is suggested that these appearances represent the presence of free radicals in the macrophage layer forming the margin of an acute plaque.

Index terms: Sclerosis, multiple; Demyelinating disease

Magnetic resonance (MR) examinations in three patients with clinically active multiple sclerosis (MS) showed ringlike structures with signal characteristics strikingly similar to those previously reported in cerebral abscesses (1). We wish to report this new finding in acute MS lesions and to offer a hypothetical explanation for the observed signal characteristics.

Material and Method

A series of 115 patients with suspected MS was examined by MR imaging over a 1-year period. No specific clinical criteria were used in case selection, beyond a requirement to document the extent and distribution of plaques. Patients were examined on a midfield (0.5 T) system: T2W axial sections (SE 2740/20/2 and 2740/100/2) were obtained, with T1-weighted (SE 500/25/2) sagittal in two patients.

Of the 115 patients, 78 were found to have MR features consistent with MS. The three reported cases had been diagnosed as having MS on the basis of clinical criteria. All had a recent history consistent with acute exacerbation, and showed multiple lesions on the T2W (2740/100) images, with a distribution typical of MS. In addition, there was, in each case, a large high signal lesion lying close to the lateral ventricle, containing a clearly defined ring of low signal intensity on the T2W images. This ring was of a constant thickness measuring approximately 2.5 mm, and was situated towards the periphery of the lesion (Figs. 1A, 1B, and 1C). On the sagittal T1W (500/15) images that were obtained in two of the patients, increase in signal intensity in the ring was observed, moderate in one and minimal in the other (Figs. 1B and 2B). In all three patients, follow-up studies showed that the size of the lesions had decreased, and the ringlike structures had disappeared, leaving only high signal lesions typical of chronic MS plaques (Fig. 3B).

Discussion

The MR appearances of MS are well established, consisting of foci of high signal intensity in myelinated neural tissue on T2W images. Such lesions vary considerably in size, and acute plaques become smaller when the patient enters remission. Previous descriptions of the margins of plaques of demyelination have referred only to the presence of contrast uptake, seen both on CT (2), and MR (3). The ring structure imaged in our cases is characterized by a fairly short T1 relaxation time, with a pronounced shortening of T2, consistent with the presence of paramagnetic material (4). Naturally occurring paramagnetic substances include oxygen, melanin, and so-called free radicals, which, because of the presence of an unpaired outer shell electron, possess strong paramagnetic properties. The presence of paramagnetic free radicals would adequately account for the MR appearances.

In plaques of demyelination, there is a histologically demonstrable structure that lies in a situation corresponding with the observed ring. It consists of a layer of macrophages containing myelin and its degradation products, up to 3 mm in thickness (Fig. 4), lying at the margin of the plaque, and separating it from the surrounding zone of edematous white matter. Active phagocytes undergo a so-called respiratory burst, a sudden surge of oxygen uptake (5), generating large numbers of free radicals. Although the experimental evidence relates to bacterial phagocytosis, it is reasonable to expect that the same

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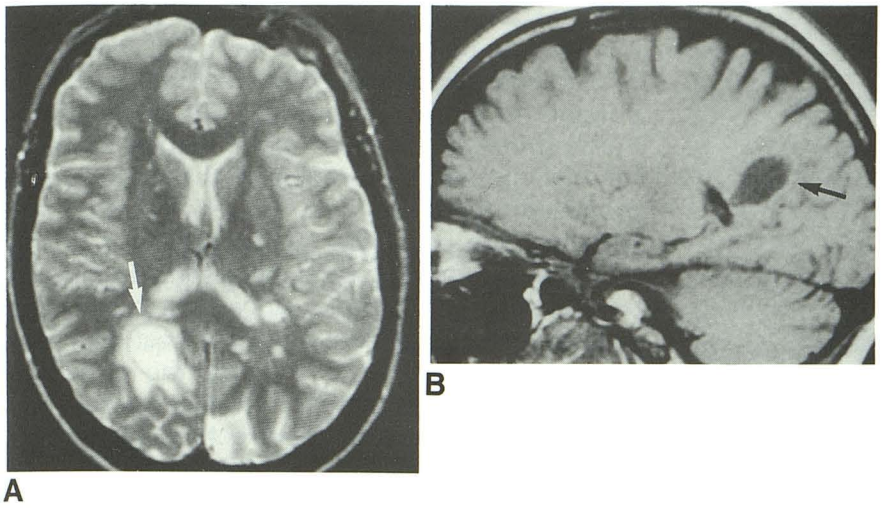

Fig. 1. *A*, (2740/100). Case 1, T2-weighted axial section, showing multiple high signal lesions typical of demyelination. A ring of low signal intensity (*arrow*) is seen in a large lesion in the paratrigonal white matter of the right hemisphere.

B, (500/25). Case 1, T1-weighted sagittal section of the same lesion (*arrow*) showing central low signal, with increased signal in the margin.

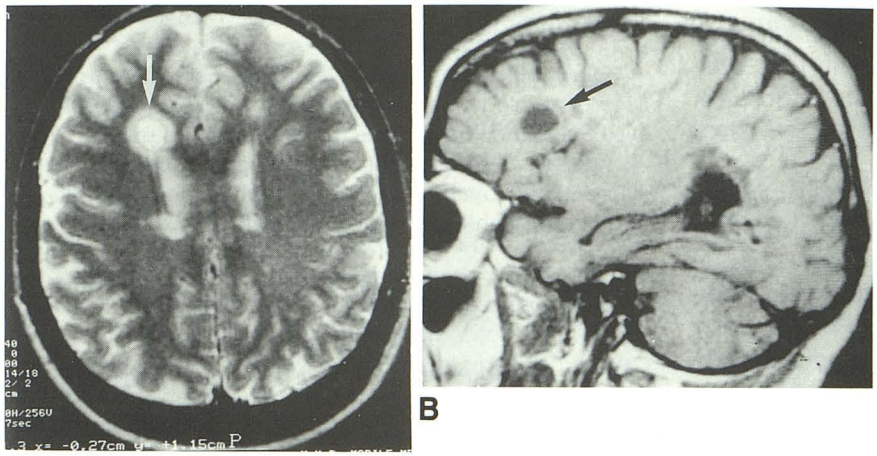

Fig. 2. *A*, (2740/100). Case 2, T2-weighted axial section, showing a low signal ring in a lesion in the right frontal lobe white matter (*arrow*), with numerous plaques in the periventricular white matter of both hemispheres.

B, (500/25). Case 2, T1-weighted sagittal section of the same lesion, showing low signal, with minimally increased signal in its margin.

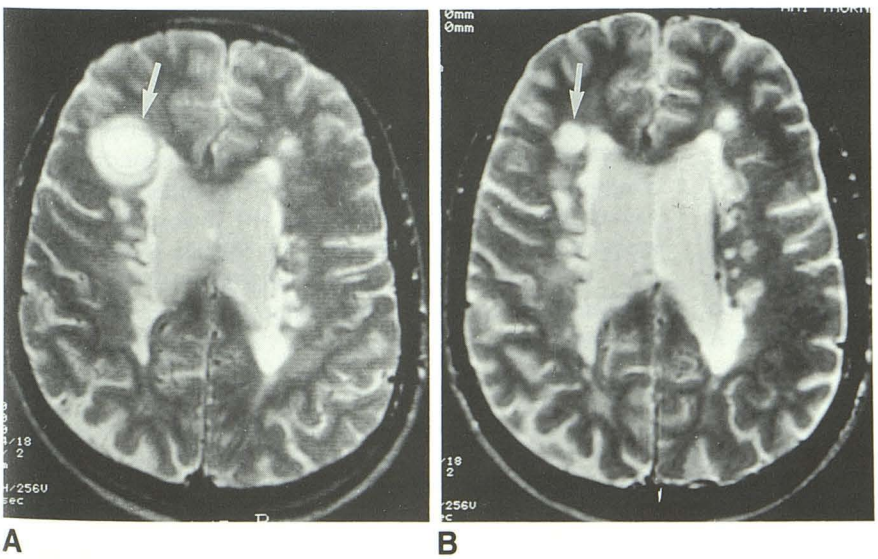

Fig. 3. *A*, (2740/100). Case 3, T2-weighted axial section, showing a low signal ring (*arrow*) in a lesion in the white matter anterior to the right frontal horn. Numerous other plaques are also seen.

B, (2740/100). Case 3, T2-weighted axial section, 8 months later, showing shrinkage of the plaque (*arrow*), with disappearance of the low signal ring.

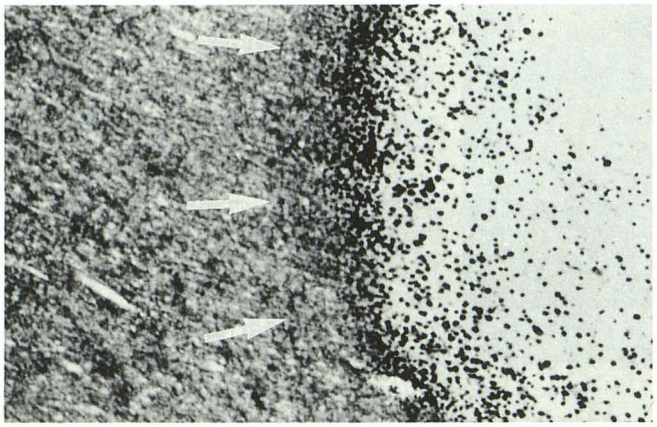

Fig. 4. Low power photomicrograph showing the margin of a plaque of demyelination, with a wide zone of macrophages (*arrows*) containing lipid material consisting of myelin degradation products. (From *Neuropathology*, Esiri and Oppenheimer, 1989, published by permission of Blackwell Scientific Publications.)

process would occur in the phagocytosis of myelin, and in its subsequent degradation. This possibility forms the basis of a hypothesis offered for the MR appearances encountered in these three patients.

In the previous description of very similar appearances in cerebral abscesses (1), abundant macrophages were a histologic feature, and, as in MS plaques, were found to contain neutral fats resulting from myelin breakdown. The influence of this on the MR signal characteristics is uncertain, but for fat to produce such low signal on T2W images it would have to be relatively anhydrous, which is difficult to reconcile with the edema found in acute MS plaques. Furthermore, such fats are always found in acute plaques, and would persist over substantial periods. The discovery of a new finding in a disease so extensively documented would however suggest a relatively short-lived phenomenon. It may be relevant that the studies were performed on a newly introduced system, and all patients were examined very soon after referral.

It was clearly not possible to obtain histologic material in our patients. Even if it had been available, it would not necessarily have been possible to prove the presence of free radicals. Furthermore, there is no experimental evidence for their presence in MS, and the explanations proposed, therefore, are entirely hypothetical. However, the possibility of the presence of free radicals in acute MS raises interesting and important issues. For example, since their occurrence would represent an element of the host response, it might be possible to monitor the effects of differing treatment protocols. Furthermore, since free radicals cause adverse effects resulting from their highly cytotoxic nature (6), there would be a potential for the development of therapy to counter these effects.

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