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BACKGROUND AND PURPOSE: **Fast fluid-attenuated inversion-recovery (FLAIR) sequences are sensitive for detecting lesions in patients with multiple sclerosis (MS). More rapid fast-FLAIR imaging of the brain can be achieved by the concomitant use of half-Fourier acquisition single-shot turbo spin-echo (HASTE-FLAIR) and echo-planar imaging (EPI-FLAIR). The present study was performed in a large cohort of subjects to assess and compare the number and volume of brain lesions detected by the fast-FLAIR, HASTE-FLAIR, and EPI-FLAIR sequences in patients with MS.**

METHODS: **Fast-FLAIR, HASTE-FLAIR, and EPI-FLAIR sequences were obtained from 46 consecutive MS patients. Lesions seen on each type of sequence were counted and classified by consensus by two observers. Lesion volumes were measured using a semiautomated segmentation technique based on local thresholding.**

RESULTS: **The quality of the fast-FLAIR images was significantly better than that of HASTE-FLAIR and EPI-FLAIR images. Fast-FLAIR revealed significantly more lesions and higher lesion volumes than did HASTE-FLAIR and EPI-FLAIR. A similar number of large lesions was detected by the three sequences, but HASTE-FLAIR and EPI-FLAIR showed significantly fewer small and intermediate lesions than did fast-FLAIR. The number of lesions seen on HASTE-FLAIR and EPI-FLAIR images was similar.**

CONCLUSION: **HASTE-FLAIR and EPI-FLAIR sequences revealed as many large MS lesions as fast-FLAIR. Because their acquisition times are only a fraction of that needed for fast-FLAIR sequences, they may be useful for making a rapid diagnosis of MS in uncooperative patients. Their reduced ability to detect smaller lesions indicates that they should not be used as a routine approach to imaging patients with MS.**

Multiple sclerosis (MS) lesions are characterized by heterogeneous pathologic features, all resulting in increased water mobility and consequently in an increase of T2 signal. Hence, T2-weighted images are traditionally used for diagnosing MS and for monitoring its natural course or as modified by treatment (1). Fast fluid-attenuated inversion-recovery (fast-FLAIR) sequences produce heavily T2-weighted images with the suppression of CSF signal by combining a long inversion time inversion-recovery sequence with a long echo time. Several recent studies have shown that fast-FLAIR sequences depict more lesions and higher lesion volumes in patients with MS than does conventional spin-echo (CSE) dual-echo imaging (2–9) owing to increased lesion conspicuity (2, 4, 8).

Imaging the brain with fast-FLAIR requires about 8 to 10 minutes. More rapid fast-FLAIR imaging of the brain can be achieved by the use of half-Fourier acquisition single-shot turbo spin-echo (HASTE-FLAIR) or echo-planar imaging (EPI-FLAIR) sequences and might prove useful for examining uncooperative, medically unstable, or claustrophobic patients. Previous studies (10–12) have compared the ability of HASTE and EPI sequences with that of CSE and fast spin-echo (FSE) sequences for detecting MS lesions of the brain and found that the ultrafast sequences depicted a similar

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number of large lesions as the more conventional techniques; however, the role of ultrafast FLAIR sequences in the imaging of patients with MS has not yet been evaluated. The present study was performed in a large cohort of subjects to assess and compare the number and volume of brain lesions detected using fast-FLAIR, HASTE-FLAIR, and EPI-FLAIR sequences in patients with MS.

Methods

Patients

We studied 46 patients with clinically definite MS (13) (33 women and 13 men). Their mean age (SD) was 39.0 (11.5) years, the median disease duration was 7 years (range, 1 to 28 years), and the median Expanded Disability Status Scale (EDSS) score (14) was 2.5 (range, 1.0 to 7.0). According to the Lublin and Reingold criteria (15), 33 patients had relapsing-remitting MS, 11 had secondary-progressive MS, and two had primary-progressive MS. Ten healthy age- and sex-matched participants served as control subjects. Approval from the local ethics committee and written informed consent from all subjects were obtained before the start of the study.

MR Imaging

MR imaging of the brain was performed at two centers by using two identical 1.5-T scanners (40 patients and 10 control subjects were scanned at one center and the remaining six patients at the other). The following sequences were performed in all subjects in a single session: a) fast-FLAIR: TR/TE/excitations = 9500/119/1, TI = 2200, echo train length = 7, matrix size = 256 × 256, readout bandwidth = 130 Hz/pixel; b) HASTE-FLAIR: TE/excitations = 87/1, TI = 2800, interecho spacing = 10.9 milliseconds, matrix size = 240 × 256, readout bandwidth = 260 Hz/pixel; and c) EPI-FLAIR: TE/excitations = 64/1, TI = 2200, interecho spacing = 0.8 milliseconds, matrix size = 128 × 128, readout bandwidth = 1250 Hz/pixel. Fat suppression was performed using a four-pulse binomial train in order to reduce chemical-shift artifacts, which are pronounced in EPI sequences owing to the narrow bandwidth in the phase-encoding direction.

For each sequence, two separate subsets of 12 interleaved sections with a thickness and an intersection gap of 5 mm and a field of view of 250 mm were acquired to obtain 24 contiguous sections that covered the entire brain from the foramen magnum to the vertex. To improve image quality, we performed 10 measurements for EPI-FLAIR. Thus, the total acquisition times were 9 minutes 10 seconds for fast-FLAIR, 4 minutes 24 seconds for HASTE-FLAIR (11 seconds per section), and 1 minute 20 seconds for EPI-FLAIR (8 seconds per measurement). Patients were carefully positioned in the scanner in accordance with published guidelines for MS studies (16).

Image Review

Image review was performed in two stages by two experienced observers who examined the hard copies side-by-side and reached a consensus as to the presence and number of lesions depicted by each technique. Because there were obvious differences among the three types of images, the observers could not be blinded to the type of sequence they were evaluating. At stage 1, each of the sequences from each subject was evaluated randomly, and lesions were marked on the hard copies. At this stage, the observers did not know to whom the images belonged. In addition, the two interpreters scored the following characteristics on a 3-point scale, with 3 being the highest score possible: confidence level for supratentorial lesions, confidence level for infratentorial lesions, and lesion-to-white matter contrast. The interpreters also evaluated the presence or absence of artifacts, their severity (affecting or reducing the confidence of the reading), and their nature. At stage 2 of image analysis, which occurred 1 month after stage 1 was completed, the two observers reviewed the three sequences obtained in each subject simultaneously in order to clarify the reasons for any differences found. During this second review, a retrospective count of lesions was performed for each sequence. When the observers agreed that a lesion not previously seen on one of the three sequences could be identified using the information from one or both of the other two sequences, this lesion was added to the count. Conversely, when a hyperintense area, which had been counted as a lesion at stage 1, was, upon reflection, judged not to be a lesion in view of the information coming from the other sequences, it was removed from the previous count. During stage 2 of image analysis, lesions were classified as small (long axis shorter than 5 mm), intermediate (long axis between 6 and 10 mm), or large (long axis greater than 10 mm). Lesions were also assigned to one of the following sites: posterior fossa (brain stem or cerebellum), periventricular (abutting the lateral ventricles), cortical-subcortical (in or immediately adjacent to the cerebral cortex), or discrete (supratentorial lesions away from the ventricles or cortex, located in the cerebral hemisphere white matter or basal ganglia). Using this information, the interpreters determined, for each sequence, the number of patients in whom the MR diagnostic criteria for MS as proposed by Paty et al (17), Fazekas et al (18), and Barkhof et al (19) were fulfilled. Because the criteria proposed by Barkhof et al (19) were based on T2-weighted and contrast-enhanced T1-weighted images, and the latter were not acquired in the present study, we just considered three of the four proposed parameters (ie, presence of at least three periventricular lesions, presence of at least one cortical-subcortical lesion, and presence of at least one infratentorial lesion).

Using the marked hard copies as a reference, a single trained technician, unaware to whom the images belonged, measured the lesion loads on the three FLAIR sequences. A local thresholding technique was used for lesion segmentation on computer-displayed images, with the marked hard copies serving as a reference. Lesions were outlined as regions of interest (ROI), and for each sequence, lesion volume was calculated by multiplying the total ROI by the section thickness. Further details about this image analysis method have been reported extensively elsewhere (20). To calculate the intraobserver coefficients of variation (COV) for measuring lesion loads on each of the three sequences, two series of measurements were performed. The interval between the two measurement sessions was at least 15 days, and, in the second session, the rater was unaware of the results obtained in the first session.

Statistical Analysis

The number of lesions detected at the end of stages 1 and 2 of the image review process was entered into the analysis. Differences in the number of lesions depicted by the three sequences at the end of each stage were evaluated by fitting the raw data into a Poisson model, considering the patients as blocks. Then, the likelihood ratio test was used to assess heterogeneity. Differences in the image quality scores were analyzed by using the Friedman test. Differences in lesion load as measured on each of the three sequences were evaluated by means of an ANOVA model. Post hoc comparisons were performed using a paired Student's *t*-test. The intraobserver COV was used to evaluate measurement reproducibility.

Results

No abnormalities were found in the healthy control subjects on any of the sequences. Table 1 re-

TABLE 1: Number of brain lesions seen using each technique at stages 1 and 2 of image review

	Stage 1	Stage 2
Fast-FLAIR	1905	1926
HASTE-FLAIR	1175	1220
EPI-FLAIR	1134	1199

Note.—Fast-FLAIR indicates fast fluid-attenuated inversion recovery; HASTE-FLAIR, half-Fourier acquisition single-shot turbo gradient spin-echo FLAIR; EPI-FLAIR, echo-planar imaging FLAIR. For further details and statistical analysis, see text.

ports the number of lesions revealed in MS patients by each of the three techniques at the end of stages 1 and 2 of image analysis. At the end of stage 1 of image analysis, a mean of 41.4 brain lesions per patient (95% confidence interval [CI] = 39.6–43.3) was seen on the fast-FLAIR images, 25.5 (95% CI = 24.1–27.1) on the HASTE-FLAIR images, and 24.7 (95% CI = 23.3–26.1) on the EPI-FLAIR images ($P < .0001$). At the end of stage 2 of image analysis, a mean of 41.9 brain lesions per patient (95% CI = 40.0–43.8) was seen on the fast-FLAIR images, 26.5 (95% CI = 25.1–28.1) on the HASTE-FLAIR images, and 26.1 (95% CI = 24.6–27.6) on the EPI-FLAIR images. The number of lesions depicted by each of the three techniques at stage 1 of image analysis was not statistically different from that detected at stage 2. At both stages, fast-FLAIR imaging showed significantly more lesions than did HASTE-FLAIR and EPI-FLAIR imaging ($P < .0001$), which detected a similar number of lesions.

Table 2 reports the mean number of lesions per patient detected by each of the three FLAIR sequences at each site. While a similar number of lesions was seen at each site on the HASTE-FLAIR and EPI-FLAIR images, a significantly higher number was seen at each site on the fast-FLAIR images ($P < .0001$ for all four sites). In Table 3, the number of small, intermediate, and large lesions seen on each of the three FLAIR images is reported. While fewer small and intermediate lesions were seen on HASTE-FLAIR and EPI-FLAIR images than on fast-FLAIR images (Figs 1 and 2), a similar number of large lesions was seen on all three types of images (Fig 2). Table 4 provides the number of images for each sequence in which previously proposed MR diagnostic criteria were met. The number of HASTE-FLAIR and EPI-FLAIR images fulfilling the criteria of Paty et al (17), Fazekas et al (18), and one of the parameters delineated by Barkhof et al (19) was only slightly lower than that of the fast-FLAIR images. Nonetheless, when more than one of the parameters delineated by Barkhof et al (19) had to be met, the performance of HASTE-FLAIR and EPI-FLAIR was much lower than that of fast-FLAIR.

The subjective scores for rating image quality were all significantly lower for HASTE-FLAIR and EPI-FLAIR than for fast-FLAIR (Table 5). Movement artifacts were seen on seven fast-FLAIR images (15%); however, only in one very disabled patient were they considered severe enough to reduce reading confidence. HASTE-FLAIR images were always blurred, and this reduced reading confidence in eight cases. The image quality of the HASTE-FLAIR technique was also reduced by the presence of flow artifacts, owing to the long echo train length, which caused blood inflow from outside the section. Admittedly, this limitation could have been overcome by the use of a flow-compensated HASTE-FLAIR sequence, but this would have inevitably resulted in an unacceptable increase in scanning time; however, such artifacts were limited to the outer parts of the images and did not reduce reading confidence (Figs 1B and 2B). Susceptibility and chemical-shift artifacts were evident on all the EPI-FLAIR images and reduced the reading confidence in 19 cases (Fig 3).

Mean lesion volumes measured on the three sequences were significantly different ($P < .0001$).

TABLE 2: Mean number (95% CI) of lesions in different sites seen on the three FLAIR sequences at the end of stage 2

	Fast-FLAIR	HASTE-FLAIR	EPI-FLAIR	*P*
Posterior fossa	2.1 (1.7–2.5)	0.5 (0.4–0.8)	0.1 (0.06–0.3)	<.0001
Periventricular	13.8 (12.8–14.9)	10.6 (9.7–11.6)	10.2 (9.3–11.1)	<.0001
Discrete	14.4 (13.4–15.6)	8.3 (7.5–9.2)	9.7 (8.9–10.7)	<.0001
Cortical/subcortical	11.6 (10.6–12.6)	6.2 (5.6–7.0)	5.6 (5.0–6.4)	<.0001

Note.—Fast-FLAIR indicates fast fluid-attenuated inversion recovery; HASTE-FLAIR, half-Fourier acquisition single-shot turbo gradient spin-echo FLAIR; EPI-FLAIR, echo-planar imaging FLAIR. For further details and statistical analysis, see text.

TABLE 3: Mean number (95% CI) of small, intermediate, and large lesions seen on the three FLAIR sequences at the end of stage 2

	Fast-FLAIR	HASTE-FLAIR	EPI-FLAIR	*P*
Small	24.5 (23.1–25.9)	13.2 (12.2–14.3)	13.1 (12.1–14.2)	<.0001
Intermediate	11.4 (10.4–12.4)	7.8 (7.1–8.7)	7.7 (7.0–8.6)	<.0001
Large	6.1 (5.4–6.8)	5.5 (4.8–6.2)	5.2 (4.6–5.9)	N.S.

Note.—Fast-FLAIR indicates fast fluid-attenuated inversion recovery; HASTE-FLAIR, half-Fourier acquisition single-shot turbo gradient spin-echo FLAIR; EPI-FLAIR, echo-planar imaging FLAIR. For further details and statistical analysis, see text.

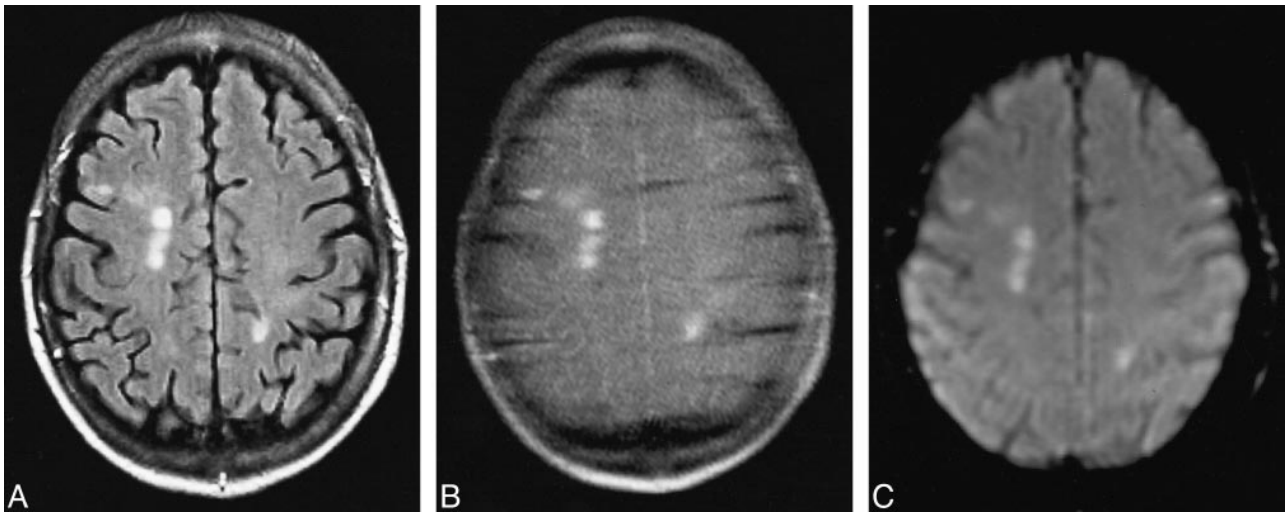

FIG 1. *A–C,* Axial fast-FLAIR (TR/TE/excitations = 9500/119/1, TI = 2200) (*A*), HASTE-FLAIR (TE/excitations = 87/1, TI = 2800) (*B*), and EPI-FLAIR (TE/excitations = 54/1, TI = 2200) (*C*) images of the brain in a patient with clinically definite MS. The same lesions are seen on all three images.

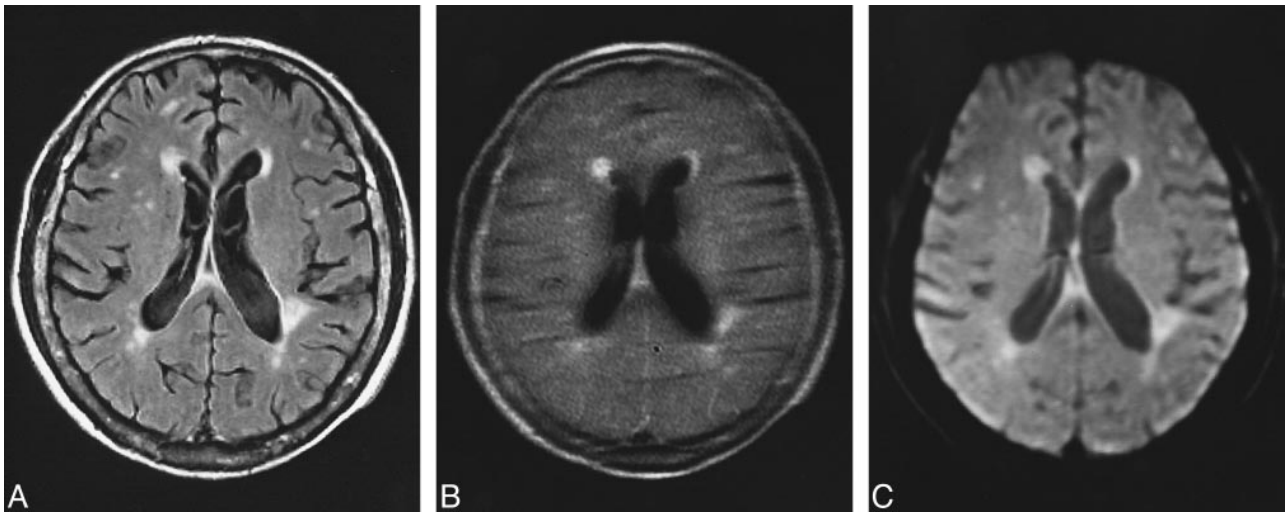

FIG 2. *A–C,* Axial fast-FLAIR (TR/TE/excitations = 9500/119/1, TI = 2200) (*A*), HASTE-FLAIR (TE/excitations = 87/1, TI = 2800) (*B*), and EPI-FLAIR (TE/excitations = 54/1, TI = 2200) (*C*) images of the brain in a patient with clinically definite MS. A similar number of large lesions is seen on all three images. Compared with *B* and *C, A* shows more smaller lesions in the white matter of both cerebral hemispheres.

TABLE 4: Number of scans for each sequence fulfilling previously proposed MR diagnostic criteria for MS

	Fast-FLAIR	HASTE-FLAIR	EPI-FLAIR
Paty et al (17)	46	44	45
Fazekas et al (18)	46	44	45
Barkhof et al (19)			
One criterion	45	44	43
Two criteria	44	40	36
Three criteria	30	14	6

Note.—Fast-FLAIR indicates fast fluid-attenuated inversion recovery; HASTE-FLAIR, half-Fourier acquisition single-shot turbo gradient spin-echo FLAIR; EPI-FLAIR, echo-planar imaging FLAIR. For further details, see text.

They were 19.8 mL (median, 18.2; standard error [SE], 1.7; range, 1.0–80.4 mL) for fast-FLAIR; 12.8 mL (median, 10.2; SE, 1.2; range, 0.2–60.0 mL) for HASTE-FLAIR; and 15.7 mL (median, 13.5; SE, 1.4; range, 0.6–69.9 mL) for EPI-FLAIR. The P values were $< .0001$ for the overall comparison and for all the post hoc comparisons. The mean intraobserver COV was 2.8% for fast-FLAIR, 3.2% for HASTE-FLAIR, and 2.8% for EPI-FLAIR.

Discussion

Brain imaging with fast-FLAIR sequences in patients with MS has several advantages over imaging with conventional dual-echo CSE sequences.

TABLE 5: Mean scores (SD) for qualitative image analysis

	Fast-FLAIR	HASTE-FLAIR	EPI-FLAIR	*P*
Supratentorial confidence level	2.98 (0.15)	2.72 (0.50)	2.54 (0.59)	<.016
Infratentorial confidence level	2.78 (0.47)	2.20 (0.62)	1.80 (0.54)	<.0001
Lesion-to-white matter contrast	2.78 (0.42)	2.43 (0.65)	2.11 (0.67)	=.0001

Note.—Fast-FLAIR indicates fast fluid-attenuated inversion recovery; HASTE-FLAIR, half-Fourier acquisition single-shot turbo gradient spin-echo FLAIR; EPI-FLAIR, echo-planar imaging FLAIR. Post-hoc comparisons were as follows: Supratentorial confidence level: fast-FLAIR vs HASTE-FLAIR, $P = .003$; fast-FLAIR vs EPI-FLAIR, $P = .0002$; HASTE-FLAIR vs EPI-FLAIR, $P = .04$. Infratentorial confidence level: fast-FLAIR vs HASTE-FLAIR, $P = .0001$; fast-FLAIR vs EPI-FLAIR, $P < .0001$; HASTE-FLAIR vs EPI-FLAIR, $P = .0004$. Lesion-to-white matter contrast: fast-FLAIR vs HASTE-FLAIR, $P = .0018$; fast-FLAIR vs EPI-FLAIR, $P < .0001$; HASTE-FLAIR vs EPI-FLAIR, $P = .0019$. For further details, see text.

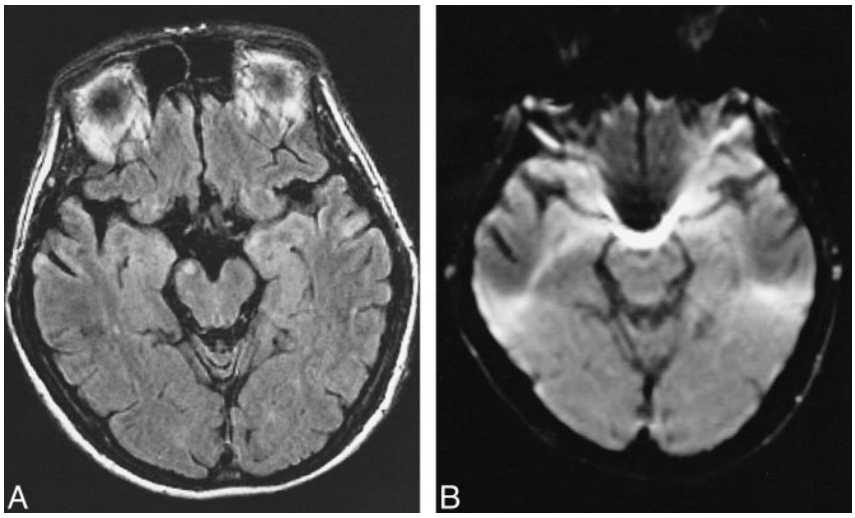

FIG 3. *A* and *B*, Axial fast-FLAIR (TR/TE/excitations = 9500/119/1, TI = 2200) (*A*) and EPI-FLAIR (TE/excitations = 54/1, TI = 2200) (*B*) images of the brain in a patient with clinically definite MS. In *A*, two lesions are visible in the right cerebral peduncle and in the white matter of the right temporal lobe. In *B*, these lesions are not visible because of the presence of susceptibility artifacts.

These include its ability to detect more lesions, particularly in the cortical-subcortical regions (2–9), the higher contrast obtained between MS lesions and other brain tissues (2, 4, 8), which results in better operator reproducibility (4, 8), and the potential to acquire more pathologically specific information about the intrinsic nature of individual MS lesions (21). Nevertheless, fast-FLAIR imaging in patients with MS is not without problems. First, fast-FLAIR has a low sensitivity for detecting lesions in the posterior fossa (4, 5, 7) and in the spinal cord (22–24). Second, the interscanner variability for lesion volume measurements on fast-FLAIR images is higher than that obtained using CSE images (25). Third, the acquisition time of fast-FLAIR sequences might be too long in the context of serial studies in which multiparametric MR approaches are used to define various aspects of the disease (ie, the extent and severity of tissue damage within and outside individual lesions) (26).

More rapid fast-FLAIR sequences might prove useful in the diagnostic MR imaging of patients with suspected MS who cannot tolerate long scanning times, to reduce the discomfort of MS patients enrolled in longitudinal studies with frequent MR sessions, such as clinical trials, and to improve image quality by reducing motion artifacts. More rapid fast-FLAIR imaging can be achieved with the use of HASTE or EPI. In the present study, significantly fewer MS lesions were seen on HASTE-FLAIR and EPI-FLAIR images than on fast-FLAIR images. This result was because of the much lower capacity of the HASTE-FLAIR and EPI-FLAIR techniques for revealing lesions smaller than 10 mm, whereas the three techniques depict a similar number of larger lesions.

The similar ability of the three FLAIR techniques to show MS lesions larger than 10 mm resulted in a comparable ability to meet the requirements of two of the most common MR diagnostic criteria for MS (17, 18). The criteria of Barkhof et al (19) were designed to predict accurately the risk of a clinically definite form of the disease developing in patients presenting with clinically isolated syndromes (CIS) suggestive of MS. Four parameters were found to be relevant: the presence of at least 1) three periventricular lesions, 2) one cortical-subcortical lesion, 3) one infratentorial lesion, and 4) one enhancing lesion (19). The diagnostic accuracy of the model increases when more of these abnormalities are detected. Clearly, the three sequences compared in this study can only be used to detect three of the four parameters (ie, those that can be assessed using unenhanced images). Our study shows that, while the diagnostic performance of the three sequences is similar when only a single parameter is considered, performance is much lower for HASTE-FLAIR and EPI-FLAIR than for

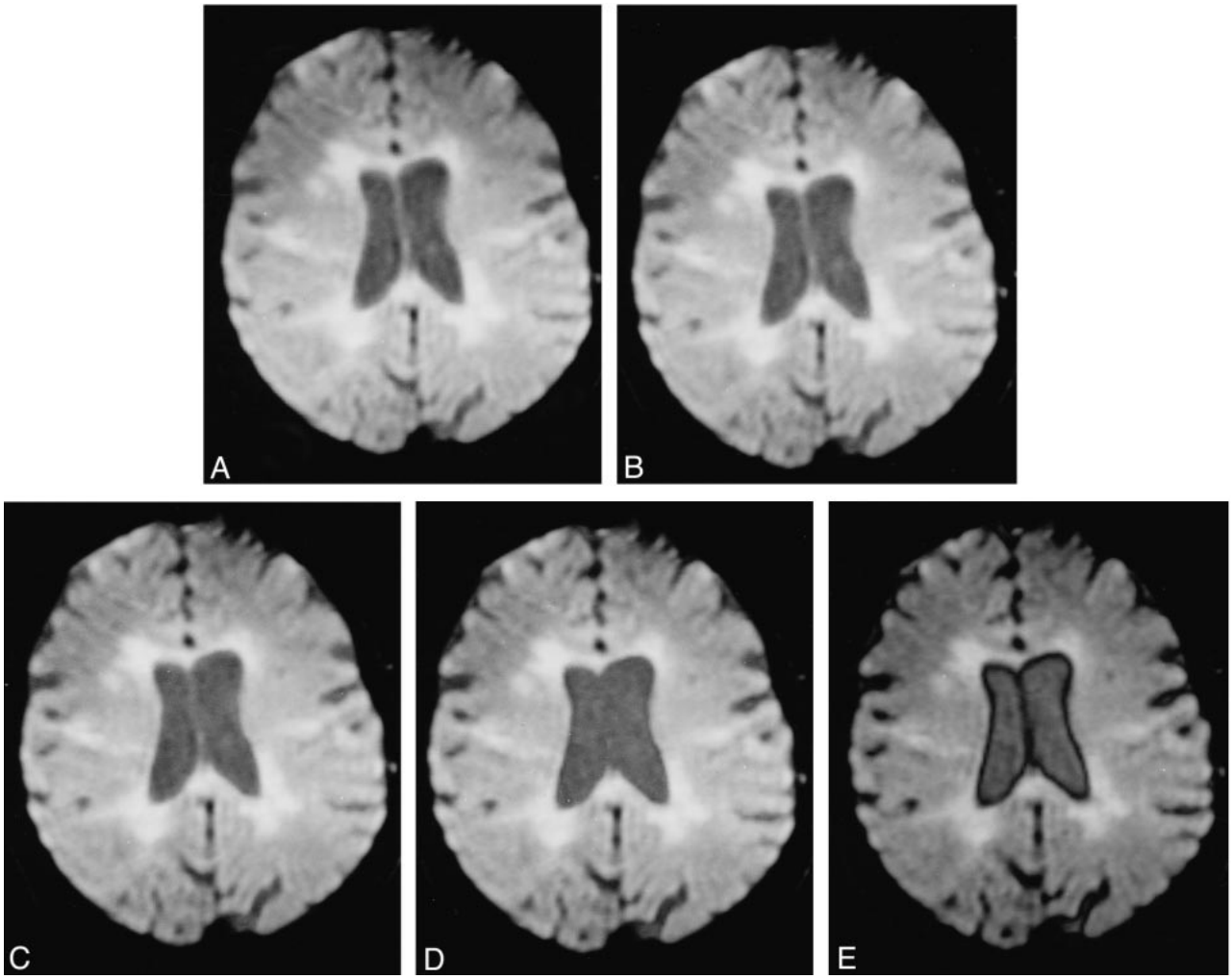

FIG 4. *A–E,* Axial EPI-FLAIR (TE/excitations = 54/1, TI = 2200) images of the brain in a patient with clinically definite MS in whom 10 (*A*), eight (*B*), six (*C*), four (*D*), and two (*E*) measurements were obtained. Multiple white matter lesions are visible on all images.

fast-FLAIR when two or three parameters are considered. This is because of their significantly lower ability to depict small or intermediate lesions, which, in some cases, inevitably results in the absence of infratentorial and cortical-subcortical abnormalities. Clearly, this is a relevant limitation when imaging patients with early MS (19) or elderly patients with concomitant microangiopathic changes (18). This, along with the fact that other pathologic conditions that can mimic MS clinically may be missed, suggests that it is inadvisable to use HASTE-FLAIR and EPI-FLAIR in patients with CIS at presentation. Moreover, the time needed to acquire the three sets of images was markedly different; thus, although not proved, the more rapid FLAIR imaging sequence may be useful in selected MS patients who cannot tolerate long acquisition times because they are claustrophobic or unable to cooperate. Poor cooperation can result from severe cognitive decline, affective disorders, or uncontrollable movements, all of which are known to be relatively frequent manifestations of MS (27). More rapid FLAIR imaging might also be used for serial scanning of patients with severe disability, thus improving our understanding of the dynamics of the advanced phases of MS, which are yet to be completely elucidated. In all these cases, the acquisition times of HASTE-FLAIR and EPI-FLAIR can be further reduced. The performance time of HASTE-FLAIR can be reduced by obtaining fewer sections. Since, in our case, the acquisition of each section took 11 seconds, one might restrict the overall acquisition time to less than 1 minute by studying only a few sections covering the periventricular areas in which MS lesions are more frequent. The acquisition time required for EPI-FLAIR images can be reduced to a few seconds by using fewer measurements. In the present study, we used 10 measurements, each of them taking 8 seconds, to achieve a sensible compromise between duration of scanning and quality of images. Clearly, reducing the number of sections in the case of HASTE-FLAIR or the number of measurements in the case of EPI-FLAIR (Fig 4) would further reduce the overall quality of the MR images. An alternative approach could be the use of non-FLAIR ultrafast T2-weighted sequences, which have been shown to

have relatively high sensitivity for detecting MS lesions larger than 10 mm (10–12).

Our finding of the reduced ability of HASTE-FLAIR and EPI-FLAIR to depict small and intermediate MS lesions is in keeping with previous data showing that HASTE and EPI reveal significantly fewer small lesions than do fast spin-echo (11, 12) and CSE (10) techniques. This is the result of several limitations of ultrafast imaging. First, EPI sequences are prone to susceptibility and chemical-shift artifacts, which may be severe enough to reduce their ability to show MS lesions located in certain anatomic regions, such as the posterior fossa or the temporal lobes (Fig 3). Second, in-plane resolution is also limited in EPI sequences in their sensitivity to T2* relaxation; moreover, although better in-plane resolution is achievable with HASTE sequences, some blurring still occurs with HASTE, owing to the T2 decay during the long readout period. Third, the effective TE of our fast-FLAIR sequence was longer than that used for the HASTE-FLAIR and EPI-FLAIR sequences. The choice of TE for our three FLAIR sequences was prescribed by scanner-specific constraints, and inevitably led to better lesion conspicuity on fast-FLAIR images. It is likely that better in-plane resolution and a longer TE would improve the ability of HASTE-FLAIR and EPI-FLAIR to depict small MS lesions; however, it is possible that scanner-specific constraints would limit the degree to which sequences can be matched, at least on conventional scanners. Therefore, our results indicate that HASTE-FLAIR and EPI-FLAIR cannot replace fast-FLAIR imaging of the brain when an accurate assessment of MS patients is needed either for routine diagnostic examinations or in the context of research trials.

In this study, we also evaluated the lesion volume detected by using the three sequences and the reproducibility of their measurements. We found that our fast-FLAIR sequence enabled us to detect a higher lesion volume than did HASTE-FLAIR and EPI-FLAIR, confirming that lesions smaller than 10 mm make up a large and significant proportion of the overall disease burden (28). Nevertheless, the reproducibility of the measurements was similar for the three techniques, despite the lower image quality of HASTE-FLAIR and EPI-FLAIR, and of a similar magnitude to those reported for T2 and fast-FLAIR techniques (4, 8, 20). The level of intraobserver reproducibility achieved with the HASTE-FLAIR and EPI-FLAIR sequences might be explained by the ample experience of the raters with the semiautomated technique, which was used in the present study to segment MS lesions.

Our HASTE-FLAIR and EPI-FLAIR sequences revealed a similar number of MS lesions, independent of the lesions' size and location. Although the time needed to acquire EPI-FLAIR images was shorter than that needed for HASTE-FLAIR images, the overall image quality was found to be slightly better for HASTE-FLAIR. In addition, EPI sequences require specialized gradient-echo hardware, which, at present, is not widely available. Thus, the choice of one or the other of the two sequences for the assessment of the previously mentioned selected cases should be based on the availability of EPI sequences on the scanner and on the patient's tolerance for the longer scanning time required for HASTE-FLAIR.

Conclusion

Our study shows that HASTE-FLAIR and EPI-FLAIR sequences depict as many large MS lesions as does the fast FLAIR sequence. Since the acquisition time is only a fraction of that needed for fast-FLAIR sequences, these techniques might be useful for making a rapid diagnosis of MS in uncooperative patients. Unfortunately, their relatively poor image quality and reduced ability to show smaller lesions indicate that they should not be used as a routine approach to the radiologic examination of patients with MS, especially when accurate monitoring of disease evolution is required.

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