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SHORT COMMUNICATION

Comparing white matter lesions on T_2 and FLAIR MRI in the Sydney Older Persons Study

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There is suggestion that magnetic resonance imaging (MRI) fluid-attenuated inversion recovery (FLAIR) sequence may be more accurate than T_2 images in detecting white matter lesions (WML) in older people. Comparative ratings of these two image sequences have not been directly investigated in very old individuals to date. We compared the ratings of periventricular and deep WML on these two sequences in a sample of 111 community dwellers (mean age 85.5 years) using semiquantitative methods. Periventricular WML were as commonly detected on T_2 as on FLAIR but were more severely rated on the latter sequence. No such bias was observed for the deep WML. With one exception, correlations between the two sets of measures were significant at the $P < 0.001$ level (range: 0.34–0.75). Intrarater reliability coefficients were moderate to excellent for most ratings. These results suggest that ratings performed on T_2-weighted images to detect WML in very old individuals are very comparable with those performed on FLAIR images although FLAIR may allow a finer grading of periventricular lesions. Absence of FLAIR does not preclude the identification of WML in this population. These findings have clinical and epidemiological relevance where the acquisition of supplementary MRI data may not always be possible.

Introduction

Brain white matter lesions (WML) on magnetic resonance imaging (MRI) are increasingly frequent with ageing (de Leeuw *et al.*, 2001), both in normal and clinical populations (Barber *et al.*, 1999). Most recent studies report WML using T_2-weighted images (Schmidt *et al.*, 1999; Garde *et al.*, 2000) where these lesions appear hyperintense. Barkhof and Scheltens (2002) recommended the use of fluid-attenuated inversion recovery (FLAIR) sequence as it discriminates genuine WML from CSF or fluid filled spaces, unlike T_2 images. They indicated that FLAIR was very useful in older subjects where grey-white matter contrast is reduced. It is also useful when measuring periventricular hyperintensities where borders between ventricles and WML may be difficult to identify at times on T_2 images.

Detection of WML on T_2 and FLAIR sequences has been compared in general clinical populations (Tomura *et al.*, 2002) and in patients with a specific illness (Gawne-Cain *et al.*, 1997) but not in very old people. Older individuals show increasing frailty that may limit their ability to undergo extensive MRI investigations. Acquisition of additional MRI data to supplement diagnostic investigations may not be always feasible. As such, it is unknown whether very old individuals for whom either T_2 or FLAIR images are available, but not both, are at a disadvantage for the detection of WML.

We compared the ratings of WML on T_2 and FLAIR in a sample of elderly community dwellers using semi-quantitative rating scales. The aim was to ascertain the respective benefits and differences between these two sequences in identifying periventricular and deep WML in individuals where MRI data acquisition may not be always optimal.

Methods

Participants were from the 6-year review of the Sydney Older Persons Study (SOPS). SOPS is a longitudinal study following an initial random sample of 630 community dwellers from the inner west region of Sydney, Australia, aged 75 years and over at the time of recruitment. The sample selection, background and methodology of SOPS have been published previously (Waite *et al.*, 2001). The 6-year review comprised

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comprehensive medical and neurological examinations, psychological and cognitive evaluations, and brain MRI. The cognitive evaluation included, amongst other instruments, the Mini-Mental State Examination (MMSE; Folstein *et al.*, 1975) and the Clinical Dementia Rating (Morris, 1993). This study received ethics approval from the Central Sydney Area Health Service.

Of the 299 remaining SOPS participants potentially available, 167 agreed to participate in this study (56%). Participants not capable of giving informed consent for high level cognitive testing or MRI procedures were excluded. Forty-five participants could not be seen because of continuing poor health or geographical isolation ($n = 33$), and MRI-related exclusion criteria such as cardiac pacemaker or claustrophobia ($n = 12$). No other *a priori* exclusion criteria were applied in order to maintain as accurate a representation of the initial SOPS random sample. Thus, 122 individuals (64 men and 58 women) took part in the current study. This procedure excluded SOPS participants with greater degree of cognitive or functional deficits and all institutionalized subjects resulting in a 'healthy survivor' cohort of 'normal' community living very old people over 80 years of age.

Magnetic resonance imaging was performed on a 1.5-T Signa scanner (General Electric Medical Systems, Milwaukee, WI, USA) within 1 month of the clinical assessment. Two sequences were obtained in the horizontal plane: a FSE2 (relaxation time (TR) = 3.6 s; time to echo (TE) = 108 ms; 5-mm-thick images with 2.5 mm gap; 22 cm field of view and a 256 × 256 matrix) and a FLAIR (TR = 10 s; TE = 140 ms; 4-mm-thick contiguous images; 22 cm field of view and a 256 × 256 matrix). Periventricular and deep WML were rated by a single radiologist who was blinded from any sociodemographic, cognitive and medical findings (see Piguet *et al.*, 2003 for detailed description of the rating protocol and Fig. 1). Briefly, periventricular WML were defined as contiguous to the lateral ventricles and recorded (in mm) in the frontal caps, lateral bands and occipital caps. Deep WML were defined as distinct from the cortical mantle and from the lateral ventricles and rated in four regions: frontal, temporal, parietal and occipital. Unlike Scheltens *et al.*'s (1993) scoring system, the number of lesions was recorded separately in each region for the following categories: '≤3 mm', '4–10 mm', '> 10 mm' and 'large confluent lesion or infarct'.

Ratings on the FLAIR and T_2 sequences were performed on two separate occasions. Intrarater reliability was ascertained by rating 24 participants randomly selected twice. Because of movement artefacts, MRI data were unavailable for 11 individuals. Consequently, results and analyses are presented for the remaining 111 participants.

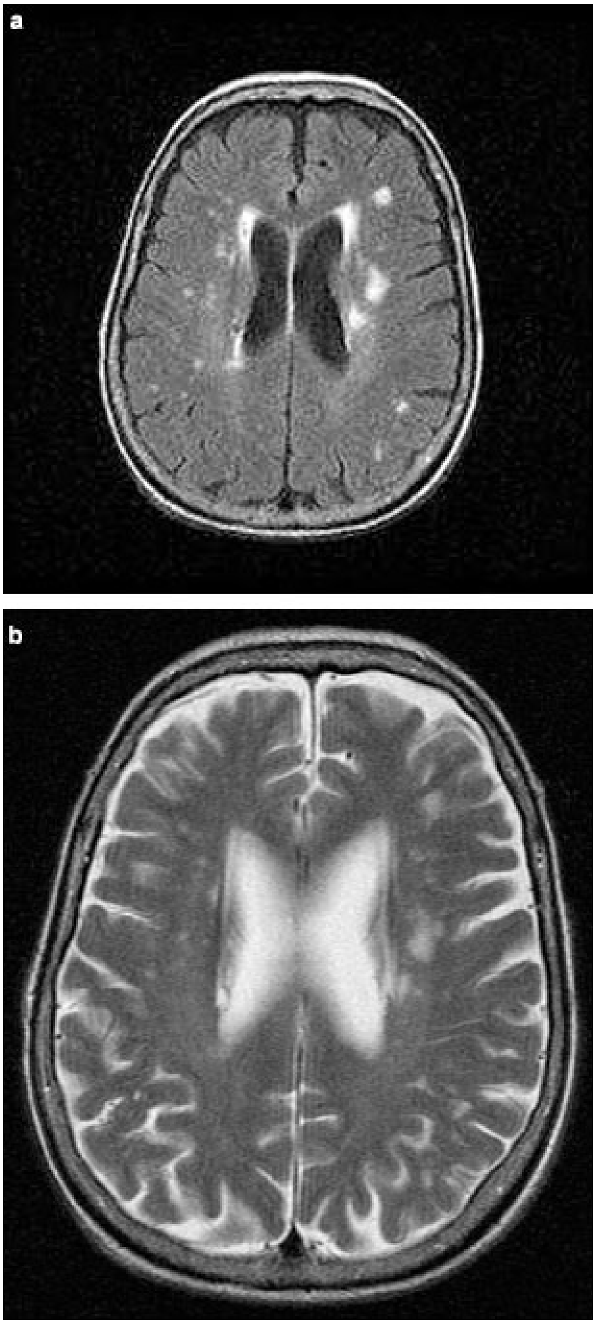

Figure 1 Example of axial (a) FLAIR and (b) T_2 images from a 92-year-old female participant. Periventricular white matter lesions are visible around the frontal caps of the lateral ventricles. Deep white matter lesions are visible in both hemispheres, more pronounced in the left hemisphere.

Results

Mean age for the sample was 85.5 ± 3.1 years (range: 81–97 years), with a mean MMSE score of 26.7 ± 2.6 points (range: 18–30 points). On the Clinical Dementia

Table 1 Descriptives of WML ratings (mean and SD), significance levels for paired *t*-tests, and correlations between T_2 and FLAIR MRI ratings

Lesion type	T_2 mean (SD)	FLAIR mean (SD)	*P*-value (two-tailed)	*r*
Periventricular WML				
Frontal caps	5.27 (3.35)	5.85 (2.88)	0.028	0.62
Occipital caps	6.23 (5.76)	7.82 (5.71)	0.001	0.67
Lateral bands	3.24 (2.15)	4.72 (3.22)	0.001	0.48
Deep WML frontal region				
≤3 mm	4.49 (4.23)	3.73 (3.58)	0.067	0.40
4–10 mm	1.36 (2.13)	1.46 (2.32)	0.589	0.63
> 10 mm	0.28 (0.74)	0.35 (1.44)	0.540	0.51
Confluent or infarct	0.05 (0.21)	0.01 (0.10)	0.045	0.44
Deep WML temporal region				
≤3 mm	1.37 (2.90)	0.77 (2.07)	0.021	0.44
4–10 mm	0.05 (0.23)	0.25 (0.79)	0.013	−0.03[a]
> 10 mm	0.00 (0.00)	0.04 (0.23)	0.103	NA
Confluent or infarct	0.02 (0.13)	0.03 (0.16)	0.566	0.40
Deep WML parietal region				
≤3 mm	10.14 (2.53)	7.47 (3.76)	0.001	0.43
4–10 mm	4.74 (4.20)	4.41(3.97)	0.246	0.73
> 10 mm	0.76 (1.33)	1.22 (2.76)	0.015	0.75
confluent or infarct	0.12 (0.40)	0.08 (0.27)	0.287	0.50
Deep WML occipital region				
≤3 mm	4.18 (4.43)	4.21 (4.14)	0.954	0.34
4–10 mm	2.05 (3.49)	2.12 (3.07)	0.786	0.64
> 10 mm	0.95 (1.11)	0.64 (1.95)	0.085	0.37
Confluent or infarct	0.08 (0.39)	0.04 (0.19)	0.132	0.59

Periventricular WML are reported in mm. For the deep WML, the total number of lesions is reported for each category. All correlations between FLAIR and T_2 ratings significant at the $P < 0.001$ level except were noted.

[a]Non-significant; NA, not applicable; WML, white matter lesions.

Rating, 61 participants scored 0 ('no dementia'), 42 scored 0.5 ('questionable dementia') and seven scored 1 ('mild dementia'). Score was missing for one participant.

Periventricular WML were rated significantly more severely on FLAIR compared with T_2 (see Table 1). In contrast, only five of the 16 deep WML ratings were significantly different between the two sequences with no specific bias. Large lesions ('confluent or infarcts') were uncommon in this sample. Most correlations between FLAIR and T_2 ratings were significant at the $P < 0.001$ level (Table 1). The only exception was the non-significant association for temporal '4–10 mm' where 106 participants showed no lesion and 5 showed one lesion on T_2 compared with 96 with no lesion and 15 with one to three lesions on FLAIR. Also, temporal '> 10 mm' lesions were detected on FLAIR but not on T_2 images.

Most intrarater reliability coefficients (Pearson's correlation coefficients) were moderate to excellent, ranging from 0.58 to 0.99 (all $P < 0.001$). There were three exceptions: T_2 frontal '> 10 mm' ($r = -0.08$; ns), FLAIR occipital '≤3 mm' and T_2 occipital '≤3 mm' ($r = 0.25$; ns and $r = 0.44$; $P < 0.01$, respectively). These low correlations were because of restricted ranges in allocated scores.

Discussion

Recently, Barkhof and Scheltens (2002) proposed the use of FLAIR to improve specificity and accuracy of detecting WML in the elderly. Our results suggest that ratings performed on T_2-weighted images are very comparable with those performed on FLAIR images. From a clinical viewpoint, both sequences allow the identification (i.e., size and location) of WML in our sample of very old community dwellers. However, T_2 and FLAIR sequences may not be entirely interchangeable. Differences in lesion severity scores and variable correlations in the WML ratings indicate an incomplete overlap between the two sequences and, possibly, differential sensitivity. For example, periventricular lesions were as common in both sequences but rated significantly more severely on FLAIR. FLAIR may allow finer lesion grading, reflected by this 'greater' severity of periventricular WML. The variable correlations between the two sequences suggested other contributions to the score variances. First, these variations may have been due to the different slice thickness in the two sequences creating different partial-volume averagings. This may have masked the presence of some lesions, particularly small ones, in the T_2 images. Secondly, the possible merging of neighbouring lesions on FLAIR may have contributed to these discrepancies. Finally, the (near) significant greater severity reported on T_2 temporal, parietal and frontal '≤3 mm' lesions may reflect the inclusion of perivascular space which appear bright on this sequence but not on FLAIR.

A possible limitation in this study may be the absence of interrater reliability measures. The objective of this study was to compare two MRI sequences and not to investigate the validity of the scale used to measure WML. In this context, the key factor was the radiologist's internal consistency across rating sessions or across image sequences, regardless of the scale and scoring system used. The moderate to excellent intrarater reliability coefficients, which were comparable with those reported by others (see Scheltens *et al.*, 1998), certainly indicates that this was achieved. Further, single-rater measurements undoubtedly reflect a clinical reality where clinical opinions are often based on individual ratings.

T_2 and FLAIR sequences have similar acquisition times (4–5 min) but the time required to perform both may be excessive for some old and frail individuals. Our findings indicate that absence of FLAIR does not preclude the identification of WML in this population. If a FLAIR sequence is not available, its addition may not be necessary for that purpose only (although it may be recommended for addressing other clinical questions). From an epidemiological perspective, these findings are also important for surveys of WML involving large numbers of participants where limited resources prevent the acquisition of two MRI sequences or where identical data collection across centres cannot be achieved.

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