FLAIR Fusion in Multiple Sclerosis Follow-up: An Indispensable Tool in Clinical Routine

Stéphane Cantin[1]; Thomas Troalen[2]; Emeline Lamain[1]; Melisa Bakir[2]

[1] Groupe Clinique du Mail, Grenoble, France
[2] Siemens Healthineers, Saint-Denis, France

Abstract

Multiple sclerosis (MS) follow-up leads to millions of brain MRI scans around the world. Depending on the number and size of inflammatory lesions, comparing successive exams to assess dissemination in time can be a challenging and lengthy process.

This article aims to describe FLAIR image fusion with *syngo*.via, and to highlight the benefits in terms of new lesion detection capacity and interpretation time saving, compared to conventional frame-by-frame 3D FLAIR comparison.

Equipment

All images were acquired using a 1.5T MAGNETOM Aera system with *syngo* MR E11 software and the 20-channel head coil. Postprocessing was performed using *syngo*.via VB10 software.

Introduction

Multiple sclerosis (MS) involves an immune-mediated process in which an abnormal response of the body's immune system is directed against the central nervous system (brain, spinal cord, and optic nerves). Magnetic resonance imaging (MRI) has revolutionized non-invasive diagnosis and follow-up for MS patients, leading to millions of MRI examinations around the world [1, 2]. MR imaging is performed before clinical modifications, during treatment to assess treatment response, and to assess dissemination of new MS lesions over time. The MAGNIMS 2016 criteria are commonly used to assess time dissemination and, in particular, the appearance of new hyperintensities on FLAIR images [3]. In some cases, detecting new lesions can be relatively cumbersome and uncertain.

The common way of identifying new FLAIR hyperintensities is via the frame-by-frame comparison of successive FLAIR sequences. This can be time-consuming, especially with patients who have a high lesion load. Moreover, the comparison is very challenging with coalescing lesions, as subtle increases in size are more difficult to detect than independent new lesions.

According to the literature, the best technique appears to be the subtraction of successive FLAIR sequences [4–5]. However, tools for the co-registration and subtraction of MRI exams acquired at different time points, or even for automatic segmentation are not always available in a clinical environment [6–7].

The third technique is FLAIR fusion, which is easily achievable using *syngo*.via postprocessing software. Three-dimensional isotropic datasets are recommended in MS patient follow-up due to the achievable high spatial resolution, thin slice thickness, and multiplanar reconstruction (MPR). A long TR of more than 7,000 ms is also recommended to better enhance lesion hyperintensity. Table 1 lists the optimized protocol parameters.

Workflow

The first step is to load two exams acquired at different time-points. This step can be automated using the auto-fetch feature of *syngo*.via connected to the PACS system. The latest FLAIR sequence (called Current) is selected first and then the oldest (called Prior) using the CTRL button

Parameters	Plane	TR (ms)	TE (ms)	TI (ms)	FOV (mm)	Matrix	Slice thickness (mm)	Slice resolution	Interpolation	Fat saturation
3D SPACE FLAIR	Sag	7000	401	2300	270 x 236	256 x 180	0.6	50%	On	On

Table 1: 3D SPACE FLAIR sequence parameters (MAGNETOM Aera 1.5T).

(both series are outlined with blue squares). The selected series are then fused by selecting MPR/MPR from the bottom-left corner of the context menu in the Current series.

To match the data as closely as possible, *syngo*.via can coregister the two volumes using the Automatic Registration option, which is located in the menu in the top-left corner of the fused image. If the system does not perform motion correction correctly, users can choose manual alignment to correct both the rotation and translation in x, y, and z.

MPR/MPR fusion and registration tools are common *syngo*.via features. Easy Reading Mode was introduced with *syngo* MR B10, making image fusion and coregistration easy in all *syngo*.via workflows. For instance, if users select the thumbnails mode in the series navigator, they can drag and drop the Prior series directly over the Current series by right-clicking and selecting 'Fuse (MPR/MPR)' from the context menu. The dropped series will become the 'overlay', and will use a 'body-heat' color look-up table (LUT) by default.

Experience shows that lesion detection is easier using a single-color LUT, such as the parathyroid-blue LUT. In our setting, the Prior series is mapped as blue while the Current series remains as grayscale. Moving the mouse over the right-hand side of the generated image allows users to adjust the contrast of the oldest series with the color LUT. The contrast is then adapted to differentiate between blue and white lesions. Keep in mind that the Current series contrast should remain unchanged, so the user should avoid moving the mouse over the left-hand side of the image. On the fused MPR, new lesions remain in white, whereas old lesions are shown in deep blue (Fig. 1A).

It is important to stress the importance of the order in which the series are selected. An incorrect order can lead to misleading fused images with the wrong color LUT. This could lead to false-negative lesion assessment, as there would be no difference in color between new and old lesions (Fig. 1B).

A description of the workflow is presented in the video available at **www.siemens.com/magnetom-world.**

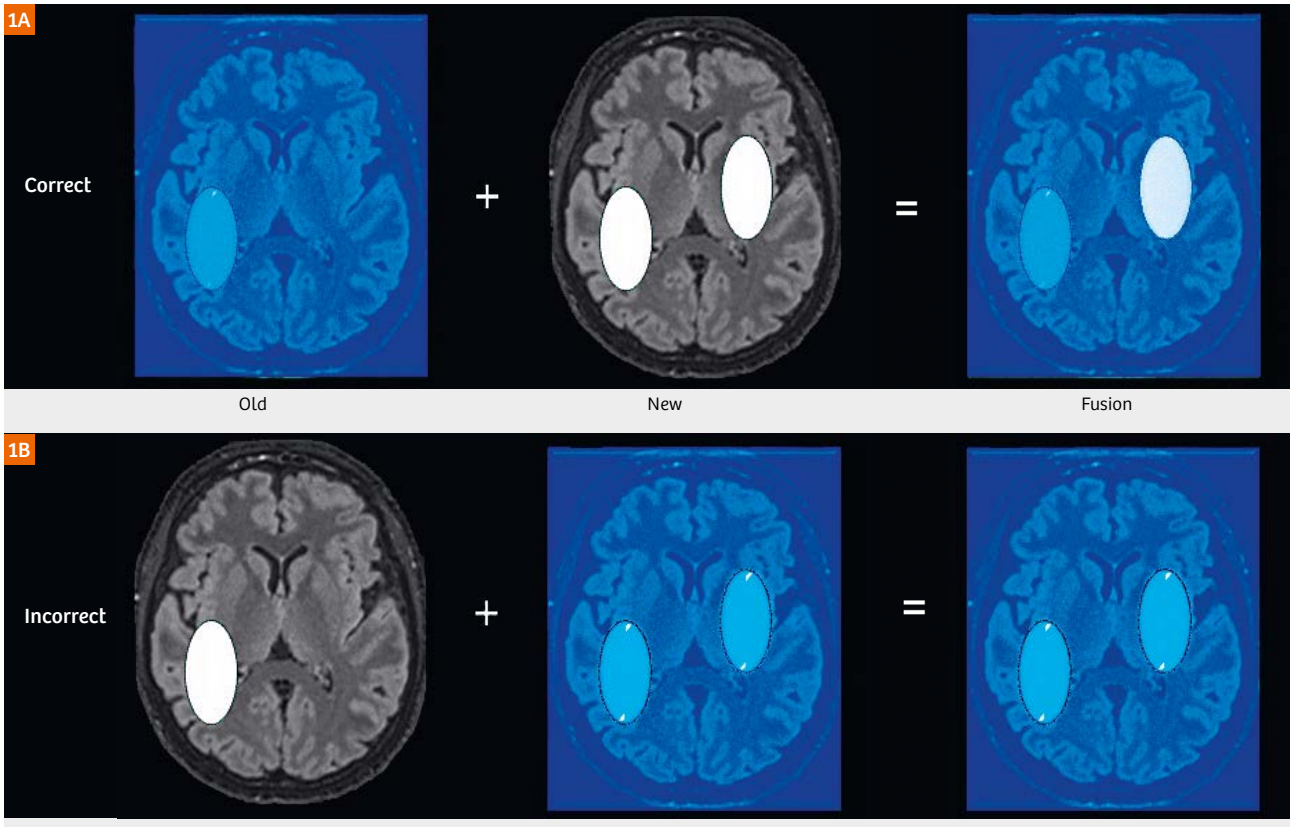

Figure 1:
Basic principle of image fusion using *syngo*.via postprocessing software.
(1A) Correct processing with the color LUT applied to the oldest series. New lesions are in white, while old lesions remain in blue.
(1B) Incorrect processing with color LUT applied to the newest series. Both lesions are colored, so analysis is not possible.

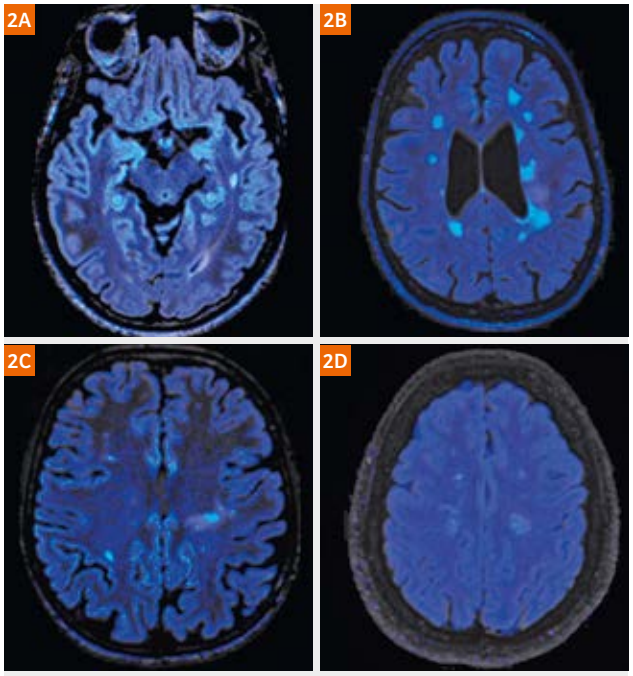

Figure 2:
Clinical example of periventricular / deep white matter lesions:
(2A) New lesion at the margin of the occipital horn of the left lateral ventricle
(2B) New lesion at the margin of the left lateral ventricle
(2C) Evolution of independent lesions into more coalescing lesions (left hemisphere)
(2D) New lesion in deep white matter, left hemisphere

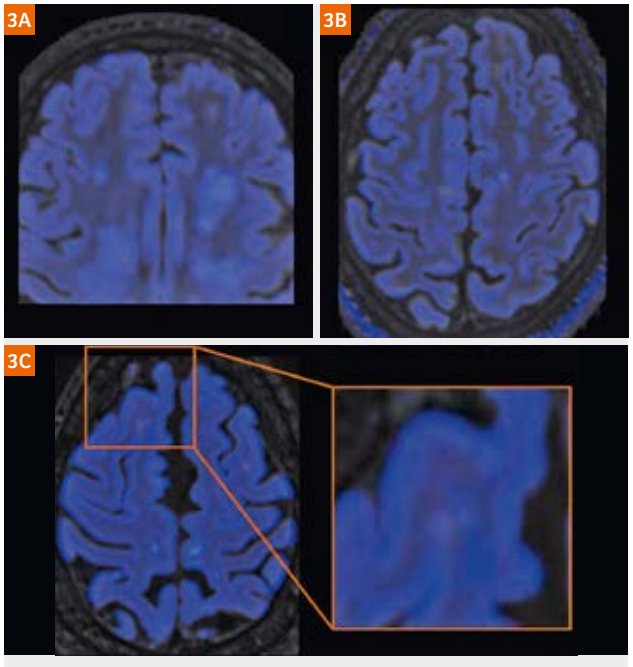

Figure 3:
Clinical example of subtle subcortical lesions:
(3A, B) Subcortical frontal lesion (right hemisphere)
(3C) New subtle subcortical lesion, magnified

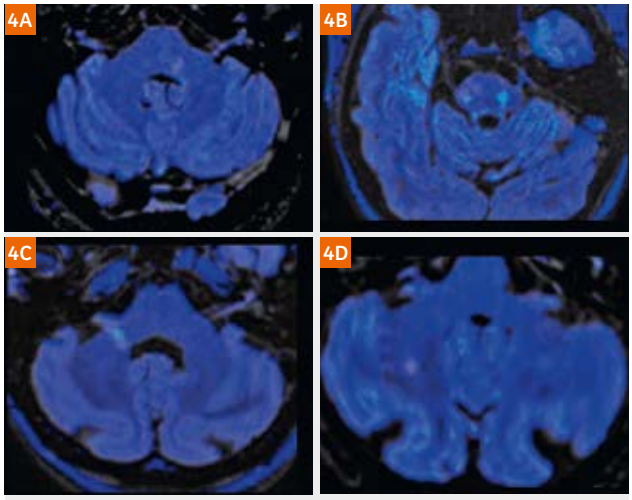

Figure 4:
Clinical example of posterior fossa lesions:
(4A, B) New pontine lesions
(4C) Growing lesion in the right cerebellar peduncle
(4D) New lesion in the right cerebellar hemisphere

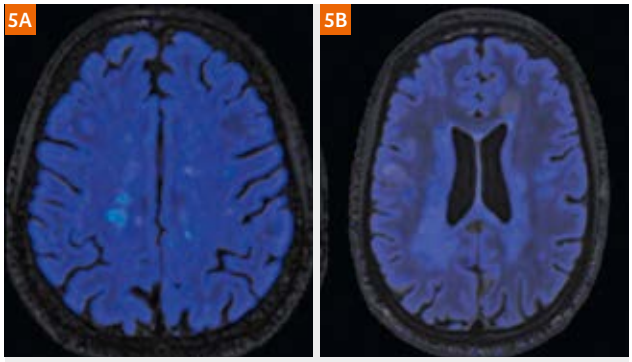

Figure 5:
Clinical example of high lesion load:
(5A) Punctate lesions
(5B) More coalescing and large lesions

This workflow, which we currently use in our imaging center, allows the detection of new lesions in all topographies: Periventricular lesions, deep white matter lesions, subcortical lesions, and posterior fossa lesions. Clinical examples are shown in Figures 2 to 4. Furthermore, this technique is particularly beneficial for patients with a high lesion load (Fig. 5).

A retrospective blinded study of 21 patients that was presented at the ASNR 55th Annual Meeting in 2017 [8] found that the fusion approach significantly reduced interpretation time, and that the number of new lesions detected was never lower than using frame-by-frame comparison (Fig. 6). The non-parametric Man Whitney test was used to compare the interpretation time of the two

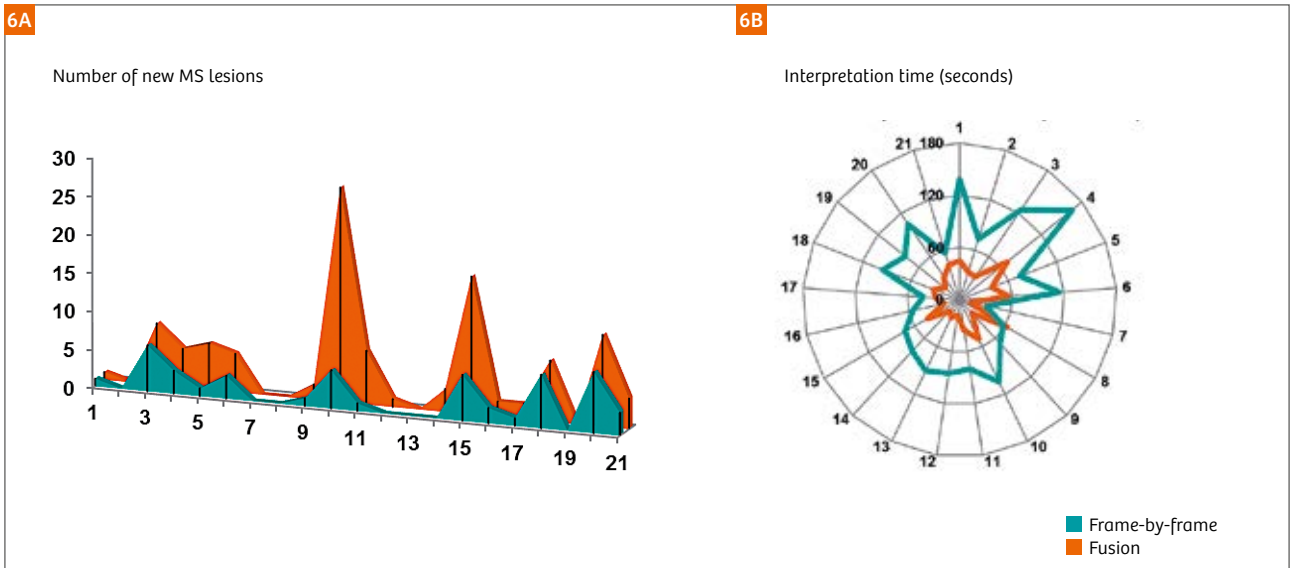

Figure 6: FLAIR Fusion vs. frame-by-frame comparison: Results from 21 patients [8].

methods and the number of new MS lesions detected by the neuroradiologist. The interpretation time with FLAIR fusion was significantly shorter, with a time-gain of about 60%, while lesion detection increased by 25%.

Conclusion

In our radiology center, FLAIR image fusion for follow-up in multiple sclerosis patients is now an indispensable tool in clinical routine. The technique is very easy to implement and is cost-effective. It allows for faster and more precise patient care, and increases the number of new lesions detected.

Other clinical applications are also possible, in particular for following FLAIR hyperintensity in microvascular micro-angiopathy, systemic diseases, or the extent of the edema surrounding expansive brain lesions.

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Contact

Stéphane Cantin
Clinique du Mail

19, avenue Marie Reynoard
38100 Grenoble
France
stephane.cantin@groupe-du-mail.com