SYNTHETIC DIR/PSIR CONTRASTS COMPUTED WITH CLINICAL SEQUENCES FOR CORTICAL LESION ASSESSMENT

Colin Vanden Bulcke[1,2], *Serena Borrelli*[1,3], *Anna Stölting*[1], Renaud Du Pasquier[4], Benoît Macq[2], Pietro Maggi[1,5]

[1]Institute of NeuroScience (IoNS), Université catholique de Louvain, Bruxelles, Belgium
[2]ICTEAM Institute, Université catholique de Louvain, Louvain-la-Neuve, Belgium
[3]Neurology Department, Erasmus Hospital, Hôpital Universitaire de Bruxelles, Bruxelles, Belgium
[4]Neurology Service, Centre Hospitalier Universitaire Vaudois (CHUV), Lausanne, Switzerland
[5]Neurology Department, Cliniques Universitaires Saint-Luc, Bruxelles, Belgium

1. INTRODUCTION

Cortical lesions (CL) serve as a valuable biomarker for improving the differential diagnosis[1] of multiple sclerosis (MS) and are associated with disease severity[2]. However, detecting CL *in vivo* remains challenging, particularly in clinical settings, due to their small size and their tendency to affect the more superficial, less myelinated layers of the cortex[3]. While specialized 3T MRI sequences such as double inversion recovery (DIR) and phase-sensitive inversion recovery (PSIR) have improved CL detection compared to using conventional sequences like fluid-attenuated inversion recovery (FLAIR) or magnetization-prepared rapid gradient echo (MPRAGE)[2], their use in clinical settings is hindered by their long acquisition time. In this study, we aim to propose synthetic DIR (sDIR) and synthetic PSIR (sPSIR) contrasts computed with clinical sequences commonly found in MS protocols to improve CL detection in clinical settings.

2. METHODS

The synthetic contrasts are based on T1/T2 ratio as previously described[4], using clinical sequences (MPRAGE, FLAIR). First, images are coregistered, N4 bias field corrected and denoised using ANTs[5], and then ravel-normalized[6]. Finally, sDIR and sPSIR contrast are derived from preprocessed FLAIR/MPRAGE and MPRAGE/FLAIR ratio respectively. The code is available as a docker[1] and as a BMAT-app[7]. The synthetic contrasts have been validated by two expert rater (S.B and A.S) on 2 datasets[2];

- 76 MS cases acquired on 3T Philips Intera and Siemens Skyra/Prisma MR scanners with the following acquired sequences: MPRAGE, FLAIR.
- 15 MS cases acquired on a 3T GE SIGNA^{TM} Premier research MR scanner with the following acquired sequences: MPRAGE, FLAIR, DIR, PSIR.

[1]colinvdb/synthetic_psir_dir
[2]Approved by local ethic committee

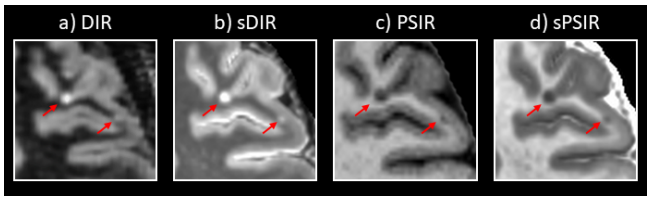

Fig. 1. Cortical lesions (red arrow) detected on DIR (a), sDIR (b), PSIR (c), sPSIR (d).

3. RESULTS

The use of sDIR and sPSIR allowed to significantly ($p < 0.01$) increase the number of CL detected (8.237 ± 10.559) when compared to using FLAIR and MPRAGE sequences (4.5 ± 5.658). No statistical difference ($p = 0.538$) was found between the number of CL detected using sDIR and sPSIR when compared to using advanced DIR and PSIR sequences (respectively, 4.667 ± 6.03 vs. 3.533 ± 3.16).

4. CONCLUSION

In conclusion, this work proposes a simple and explainable method for generating synthetic contrasts using clinical sequences commonly found in MS protocols, achieving similar CL detection rates as using advanced research DIR and PSIR sequences. This approach holds promises for expanding the utilization of CL as a valuable biomarker of both MS diagnosis and prognosis in routine clinical practice.

5. REFERENCES

[1] Cagol A. et al, "Diagnostic performance of cortical lesions and the central vein sign in multiple sclerosis," *JAMA neurology*, vol. 81, no. 2, pp. 143–153.

[2] Calabrese M. et al., "Cortical lesions in multiple sclerosis," *Nature Reviews Neurology*, vol. 6, no. 8, pp. 438–444, Number: 8 Publisher: Nature Publishing Group.

[3] Filippi M. et al., "Assessment of lesions on magnetic resonance imaging in multiple sclerosis: practical guide-

lines," *Brain: A Journal of Neurology*, vol. 142, no. 7, pp. 1858–1875.

[4] Manning A.R. et al., "T1/t2 ratio from 3t MRI improves multiple sclerosis cortical lesion contrast," *Journal of Neuroimaging*, vol. 33, no. 3, pp. 434–445.

[5] Avants B. et al., "Advanced normalization tools (ANTS)," *Insight J*, vol. 1–35.

[6] Reinhold J.C. et al., "Evaluating the impact of intensity normalization on MR image synthesis," *Proceedings of SPIE–the International Society for Optical Engineering*, vol. 10949, pp. 109493H.

[7] Vanden Bulcke C. et al, "BMAT: An open-source BIDS managing and analysis tool," *NeuroImage: Clinical*, vol. 36, pp. 103252.