Definition and Classification of Registration Artifact ("Yin Yang" Artifact) on MR Subtraction Imaging in Multiple Sclerosis (MS): a Pilot Study

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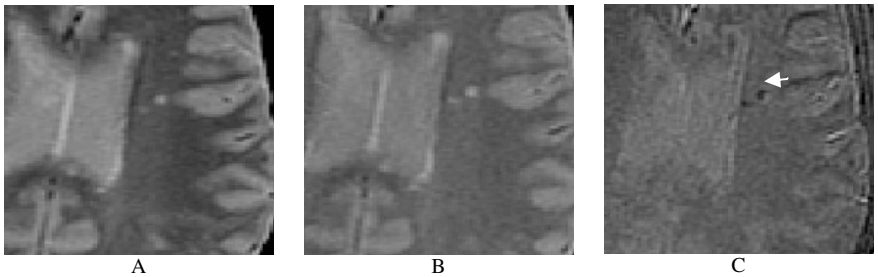
Introduction

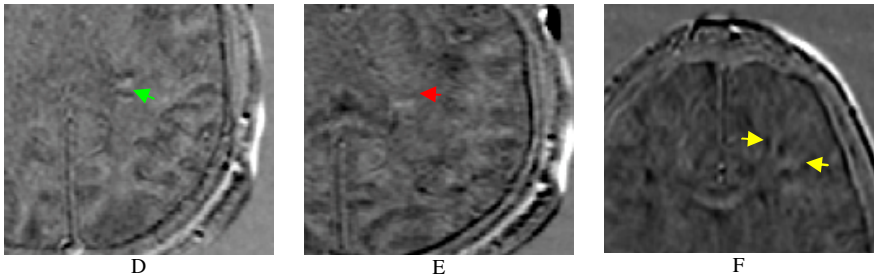
The frequent use of serial studies has generated an increase in the use of registration and subtraction techniques in MS [1,2]. However, mis-registration artifacts on subtraction images can cause artifacts that mimic actual changes. A prominent artifact of this nature is the Yin Yang artifact (YYA). YYA is a counterpoised increase and decrease of signal changes around lesions on subtraction images. Very few studies have addressed artifacts on subtraction images [3,4]. We analyzed subtraction artifacts based on the underlying registration mechanism, to facilitate in depth understanding of the their causes and accuracy in interpreting lesion progressions on subtraction images.

Materials and methods

Ten MS patients (2 men/8 women; 2 Relapsing/Remitting MS, 2 Secondary Progressive MS, 1 Primary Progressive MS, 5 unknown MS type, mean age 53.85 years) were enrolled in this study with an inter-scan interval of thirty minutes. Each participant underwent MR imaging using a polarized head coil (1.5 Tesla, Signa, GE Medical Systems). Dual echo PD/T2 weighted MR images ($TR/TE_1/TE_2$=3000/30/80 ms, 192 phase-encoding steps, 0.93×0.93×3 mm^3 voxel size) were acquired, co-registered, intensity normalized and subtracted [2]. 3D Gaussian filter with a standard deviation of 0.68 and a kernel size of 3x3x3 pixels [2] was applied before subtraction to reduce partial volume artifacts from anisotropic voxel size. Baseline, coregistered and subtracted images were compared to identify YYA around the lesions. YYA were classified as four types (I, II, III and IV) according to the predominant mis-registration orientation direction: type I: right-left (x-axis), type II: anterior-posterior (y-axis), type III: cranial-caudal (z-axis) and type IV: combined dimensions. The number of lesions with YYA and their percentages were calculated and compared to the total number of lesions and other artifacts (OA).

Results





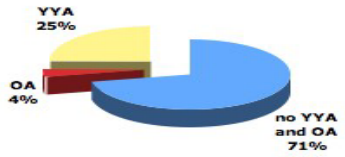


Chart1: Percentage of Artifacts (YYA and OA) and no Artifact

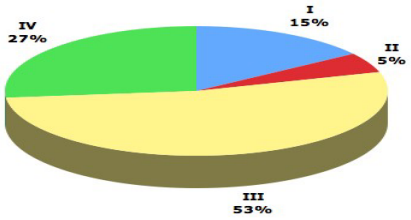


Chart2: YYA Classification Percentage

Figure A, B and C are examples for this study, which are respectively baseline image (A), registered image (B) (from 30 minute re-scan) and subtraction image (C=A-B) in one MS patient. Figure C, D, E and F show subtraction images of, respectively, type I (white arrow), II (green arrow), III (red arrow) and IV YYA (yellow arrows) in the predominant mis-registration orientation direction: right-left (x-axis), anterior-posterior (y-axis), cranial-caudal (z-axis) and combined dimensions (x and y axis).

Chart 1 and 2: Type IV (27%) and type III YYA dominated mainly in four artifacts, and type III YYA occurred 53%. The frequency of type III was almost 3.5 times that of type I (15%), ten times more than type II (5%)and nearly twice the occurrence of type IV (chart 1). In the 10 scan-rescan MS patients, out of 321 lesions, YYA and other artifact appeared 25% and 4%, respectively. 71% of all lesions showed no artifacts (chart 2).

Discussion

Type I and II of YYA appeared less frequently than that of type III and type IV. This result can be explained by limited movement of patients on right-left (type I), anterior-posterior (type II) direction due to restriction by head restraints, most of which can be corrected by image registration. However, type III and type IV artifact were generated because of rotation movement, which is more difficult to be corrected by registration [1]. YYA definition and identification have improved new MS lesion detection, yielding significant correlation with clinical measurement [3]. In the future, 3 D lesion volume comparison study could be used to improve YYA identification.

Conclusion

YYA was identified and classified into four subtypes by radiologists according to mis-registration orientation, corresponding to patients movement on right-left, anterior-posterior, cranial-caudal and combined shifting dimension respectively. Type III and IV occurred more frequent than type II and I.

References:

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2.Meier, D.S. et al., *Time-series analysis of MRI intensity patterns in multiple sclerosis.* Neuroimage, 2003. 20(2): p. 1193-209.
3.Yang D., et al Segmentation of Subtraction Images for Measurement of Lesion Change in Multiple Sclerosis. AJNR, 2008 February (in press)
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