Diffusion weighted imaging in head-and-neck cancer: comparison between echo planar and turbo spin echo sequences

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Purpose

Diffusion weighted magnetic resonance imaging (DW-MRI) is a functional imaging technique, increasingly used for tumor and recurrence diagnosis, response prediction and monitoring. Due to the high contrast between tumor and surrounding tissue, DW-MRI might also be a candidate to facilitate radiotherapy target definition. However, the use of DW-MRI for tumor delineation in radiotherapy (RT) is hampered by geometric distortions, particularly in head and neck cancer due to susceptibility differences from air/tissue transitions [1]. These distortions are related to the echo planar imaging (EPI) sequence in combination with an anatomically challenging region causing B0 inhomogeneities.

To improve the geometrical accuracy, a non-EPI method is preferable. Turbo spin echo (TSE) imaging is a robust method concerning geometrical accuracy. However, bulk motion during the diffusion weighting gradients causes a violation of the CPMG condition, leading to unstable echo trains and destructive signal evolution in TSE sequences. Split acquisition of fast spin echo signal (SPLICE) has been proposed to solve this issue [2].

In this work, DW-EPI images were compared with DW-SPLICE images to assess the applicability for RT treatment planning.

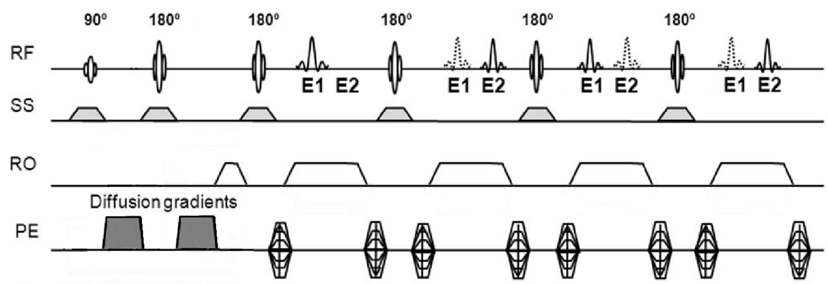

Figure 1: DW-SPLICE sequence diagram. E1 and E2 are the 2 separate echo families formed alternatively from spin echoes (solid line) and stimulated echoes (dashed line). The reconstructed E1 and E2 magnitude images were averaged into a combined image.

Methods

Eight patients (6 pre treatment, 1 followup and 1 during treatment) were scanned in a RT mask at 3.0T (Philips Achieva) using Flex-M coils. The standard RT treatment planning protocol was using with the addition of the DW-SPLICE sequence (figure 1).

Diffusion sequences

DW-EPI: TR/TE 3474/68 ms; EPI factor 85; max b-value 1000 s/mm^2 with 6 averages; 6 b-values in total; acquired voxel size 1.4 x 1.4 mm^2; slice thickness 3.0 mm + 1 mm gap; total number of slices 30; FOV 230 x 230 x 120 mm^3; SENSE factor 2; fat suppression SPIR; acquisition time 2m57s.

DW-SPLICE: TR/TE 14109/123; TSE factor 53; TSE echo spacing 7.4 ms; TSE refocusing pulse angles 50°; max b-value 800 s/mm^2 with 6 averages; 2 b-values in total; acquired voxel size 2.0 x 2.0 mm^2; slice thickness 4.0 mm; total number of slices 30; FOV 250 x 250 x 120 mm^3; SENSE factor 1.5; fat suppression SPIR; acquisition time 5m10s.

The images were scored on tumor conspicuity, distortions, fat suppression and contrast/noise using a 4 point grading scale (with 1 the worst and 4 the best score) by an experienced MR physicist. The scores were averaged over all patients.

Results

Figure 2 shows representative images of 2 patients, comparing DW-SPLICE with DW-EPI. Tumor conspicuity (3.12±1.13 vs. 1.57±0.98) was better on DW-SPLICE and the distortions (4.0±0.0 vs. 1.86±0.69) were less on DW-SPLICE. Fat suppression was slightly better on DW-SPLICE (3.29±0.76 vs. 2.33±0.88) and the contrast/noise was comparable (2.75±0.71 vs. 3.0±0.0).

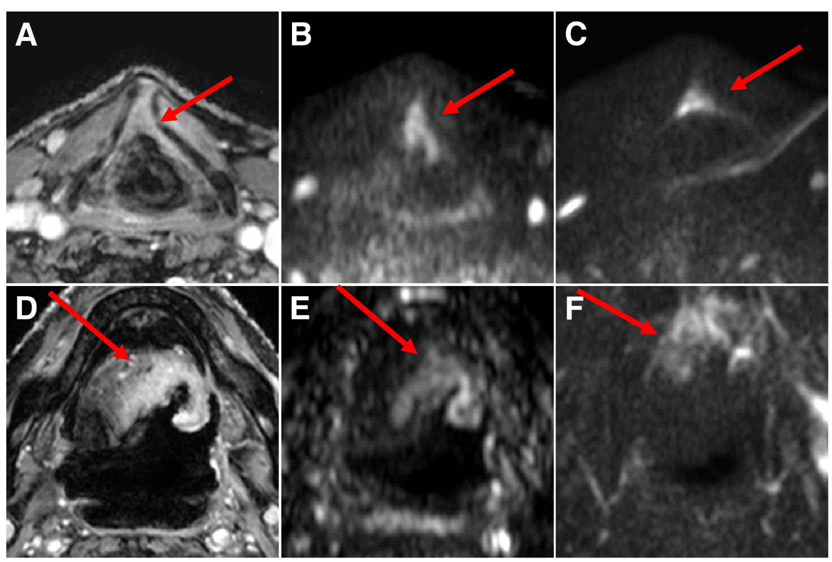

Figure 2: Scans of 2 pre treatment patients. T_1w mDixon post-contrast (a, d); DW-SPLICE, b800 image (b, e); DW-EPI, b1000 image (c, f). In both patients (top and bottom row) tumor is more obviously visible in the DW-SPLICE b800 image.

Conclusion

Current DW-EPI images are, due to the geometric distortions, unsuitable for delineation purposes for radiotherapy treatment planning. The presented alternative, DW-SPLICE, can produce distortion free images at the cost of longer acquisition times and increased blurring.

References

1. Le Bihan D et al. J. Magn. Reson. Imaging 2006; 24: 478–488.
2. Schick F. Magnetic Resonance Medicine 1997;38:638-644.