# A complete neuroimaging protocol with optical prospective motion correction

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**Introduction and purpose:** Prospective motion correction is gaining popularity to prevent motion artifacts in MRI of the brain [1]. In many cases, an optical system, such as a camera, is used to track head position. Many authors have claimed, or implied, that one of the advantages of the technique is that it is applicable to any imaging sequence [1-3], since it operates independently from the MRI scanner. This would give it an advantage over MR-based methods such as PROMO, which require time in the sequence to play out navigator information. The purpose of this work was to test this claim by developing and evaluating a complete neuroimaging protocol compatible with optical prospective motion correction.

**Table 1. Neuroimaging protocol equipped with optical motion correction**

| | | |
|---|---|---|
| 1 | Localizer | 0:09 |
| 2 | Asset calibration | 0:07 |
| 3 | *Ax T1 FLAIR* | 3:32 |
| 4 | *Ax T2 FLAIR* | 5:29 |
| 5 | *T2w FSE* | 2:33 |
| 5 | *Ax T1 SE (CE)* | 3:15 |
| 6 | *Ax DWI* | 1:42 |
| 7 | *3D TOF* | 3:48 |
| 8 | *Ax SWAN* | 3:25 |
| 9 | *3D ASL* | 4:43 |
| 10 | *BRAVO* | 3:59 |

**Methods:** *Sequence development* – A protocol consisting of the most frequently used and clinically relevant sequences for our 3 T MR scanner (GE Healthcare) was assembled (Table 1). All sequences shown in italics in Table 1 were modified to allow prospective motion correction, based on head position information sent in real time over the network. A potential confounding factor is that the camera is mounted on the head coil, which moves with the patient table during the transition from one scan to the next (depending on the slice position specified). To account for this, the patient table position, *t0*, at the time of cross-calibration information is saved with the cross-calibration transformation. Any new table position, *ti*, is measured by the table motion encoder of our scanner and sent automatically to the tracking software at the beginning of every scan. The translation vector component of the homogenous transformation matrix is then updated such that z, the component of the translation vector describing the shift in the z direction is replaced with *zi*, i.e.,

$$\mathbf{H} = \begin{bmatrix} \mathbf{R} & \mathbf{v} \\ (0\ 0\ 0) & 1 \end{bmatrix}, \text{ where } \mathbf{v} = \begin{bmatrix} x \\ y \\ zi \end{bmatrix}, \text{ and } zi = z + (ti - t0).$$

*Hardware* – The optical tracking system used in this work was a head coil mounted camera, similar to that published by Aksoy et al. [4], but running at a frame rate of 60 Hz. The standard 8-channel head coil was used for all experiments in this work.

*In vivo experiments* – Two volunteers were asked to perform repeatable head motion during scanning, consisting mainly of side-to-side rotations (the motion component with the greatest freedom of movement in our head coil). Imaging was performed using the sequences in the protocol on the two volunteers, excluding the contrast-enhanced T1 spin echo protocol.

**Results:** Integration of optical prospective motion correction was possible for all sequences in our chosen protocol. Fig. 1 shows example results. The 3D ASL and SWI (SWAN) results are published separately, so are not included here.

**Discussion:** This work indicates that it is possible to integrate optical prospective motion correction into all non-contrast-enhanced sequences typically used for neuroimaging in our institution. While some of these sequences appear to benefit more than others from motion correction, in all cases image quality was improved in experiments with normal volunteers. In future, the reference pose (position and orientation) should be set at the beginning of the localizer. In this way, motion correction would not only be performed during each sequence (preventing artifacts), but would also automatically align all individual scans in the imaging protocol.

**Conclusion:** Optical prospective motion correction can form a comprehensive motion correction solution for neuroimaging. Mounting a camera on the head coil produces good results when the effect of table motion on cross-calibration is accounted for.

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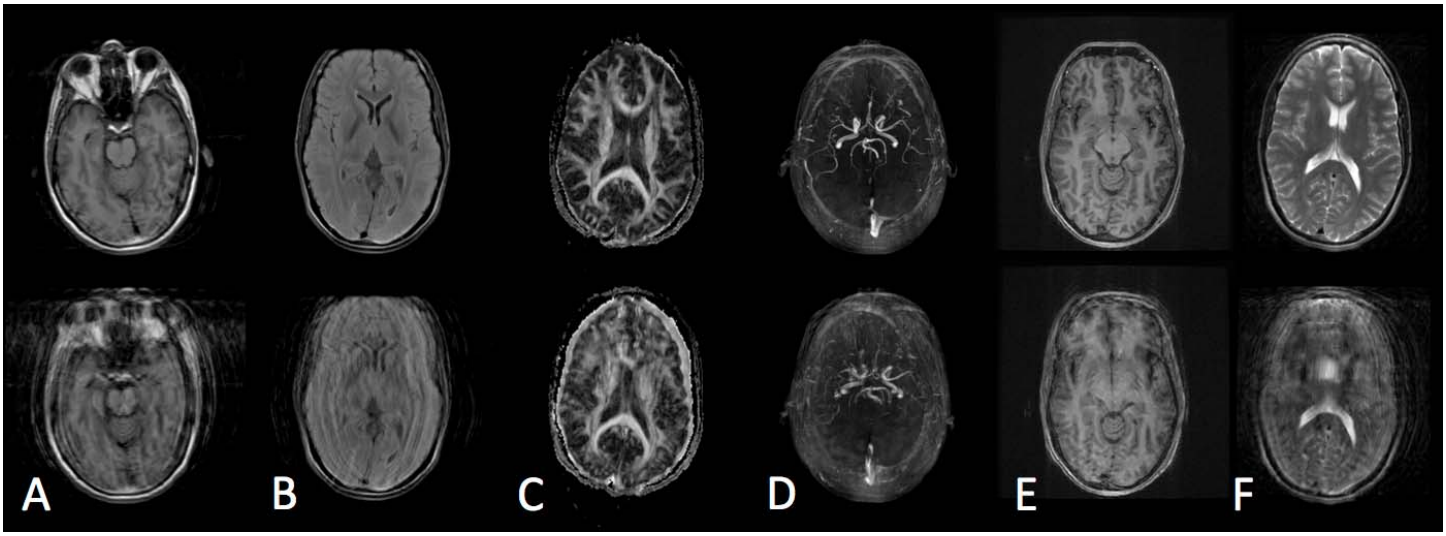


Fig. 1: Results of the in vivo experiments using neuroimaging protocol on healthy subjects with the prospective motion correction off (bottom row) and on (top row): (A) T1 FLAIR, (B) T2 FLAIR, (C) DTI, (D) 3D TOF, (E) BRAVO and (F) FSE