FEASIBILITY STUDY FOR IMPLEMENTING LOW-FIELD MRI WITH SPIO NANOPARTICLES FOR ENDOVASCULAR INTERVENTIONS

AN ALTERNATIVE TO X-RAY GUIDED TECHNIQUES

J.K. van Zandwijk, MSc [1,2,4], F.F.J. Simonis, PhD [1,2], R.H. Geelkerken, MD PhD [3,4], R. Meerwaldt, MD PhD [4], F.G. Heslinga, MSc [1], B. ten Haken, PhD [1,2]

1 MIRA Institute for Technical Medicine and Biomedical Technology, University of Twente, Enschede, The Netherlands
2 Magnetic Detection & Imaging (MD&I), University of Twente, Enschede, The Netherlands
3 Faculty of Science and Technology, University of Twente, Enschede, The Netherlands
4 Department of Vascular Surgery, Medisch Spectrum Twente, The Netherlands

Correspondence to: j.k.vanzandwijk@utwente.nl

PURPOSE

Intermittent claudication (CLI) is often treated using a minimally invasive approach with X-ray guidance. Low field magnetic resonance imaging (lf-MRI) using super-paramagnetic iron oxide (SPIO) particles could be a *positive contrast* [1], *radiation-free* alternative for guidance due to its *open system configuration*.

METHODS

The proposed surgical workflow when using lf-MRI is adapted with respect to fluoroscopic techniques (**Figure 1**). The following series of experiments was conducted in this research using an ESAOTE G-scan Brio 0.25T MRI system:

1. A clinically relevant range of SPIO [1,2] nanoparticles concentrations (0 mM – 4.096 mM) was scanned using T_1-weighted 2D spin echo sequences (**Figure 2**). MR parameters were TR = 600 ms, TE = 26 ms, FA = 90°, acquisition matrix 160 x 160, FOV = 110 x 110 mm, reconstructed resolution = 0.43 x 0.43 x 2 mm.
2. Experiments were performed on a phantom mimicking iliac and femoral mean blood flow using 3D balanced and spoiled gradient echo sequences. MR parameters were TR = 38 ms, TE = 16 ms, FA = 65°, acquisition matrix 192 x 128, FOV = 180 x 180 mm, reconstructed resolution = 0.43 x 0.43 x 2 mm.
3. Subtraction images and maximum intensity projection images were created (**Figure 3**).

RESULTS

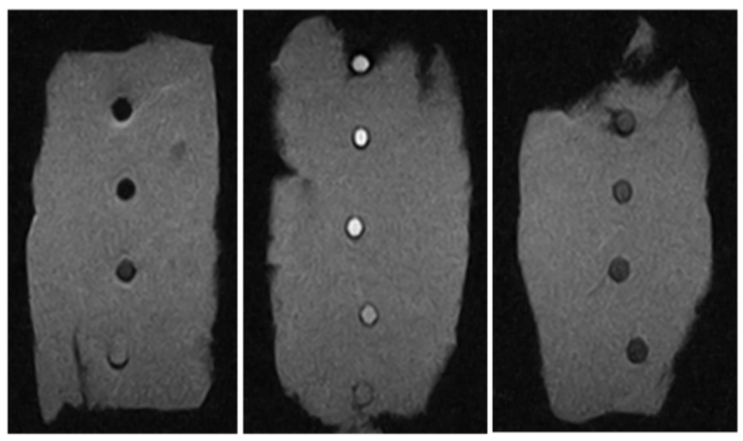

FIGURE 2 Small tubes filled with a range of SPIO concentrations (circles in image), inside chicken breast. The optimal CNR was found at a concentration of 64µM iron.

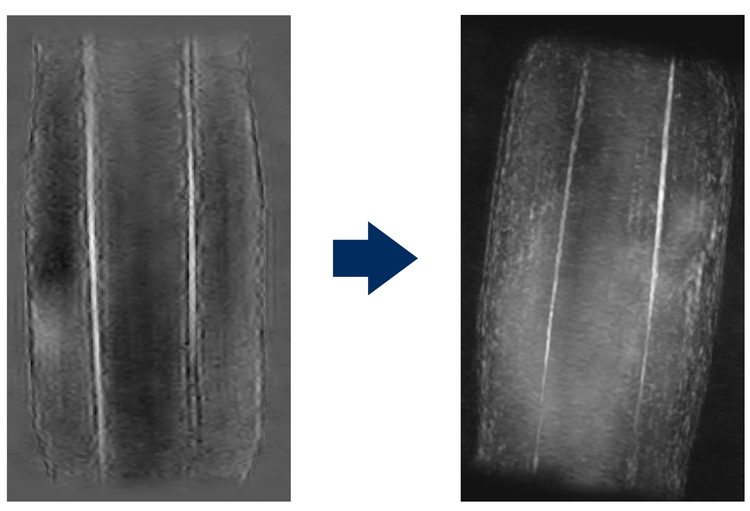

FIGURE 3
Left: subtraction of the MRI flow scan without SPIO (60 µm Fe) from the scan with SPIO contrast.
Right: 3D maximum intensity projection (MIP) of the resulting subtracted image.

DISCUSSION

- **Fusion with high quality pre-operative imaging** should be used extensively in an lf-MRI intervention, to compensate for the low temporal resolution (acquisition times > one minute).
- Stenosis and structures of **at least 1 mm** must be distinguishable by the fused techniques to operate successfully and safely.
- 3D-MRI can provide the operator with **cross-sectional information** of the vessel which can ideally be used to guide catheter insertion.
- Although we used pre-established concentration levels in phantom models, **contrast injection techniques and contrast agent clearance rate** determine the injection quantities in vivo.

CONCLUSION

The proposed workflow can work in practice, with adequate spatial resolution using lf-MRI. However, temporal resolution should be increased to make this technique feasible for guiding endovascular interventions.

REFERENCES

[1] J. P. Walker et al., Ann. Vasc. Surg., 2015.
[2] S. S. Vasanawala et al., Magn. Reson. Med., 2016.

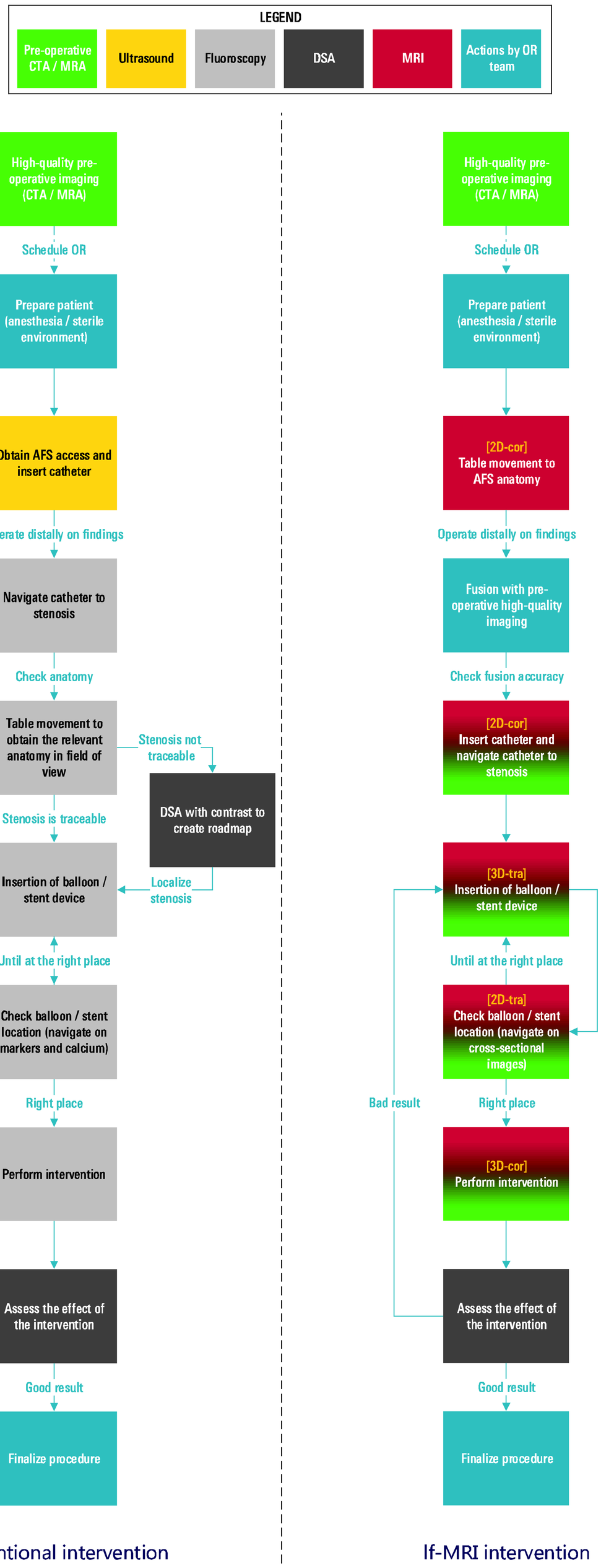

FIGURE 1 Workflow diagrams of a typical hybrid operation (intervention) on a patient with CLI using fluoroscopy (**left**) or low-field MRI (**right**). Note that the different colors depict the use of different imaging modalities before and during the intervention. The final goal is to perform the final effect assessment also with the lf-MRI modality instead of DSA.

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