COMPARISON OF POSITIVE CONTRAST TECHNIQUES FOR THE MRI VISUALIZATION OF IRON-LOADED MESH IMPLANTS IN HUMANS

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Target Audience

Over 1.5 million polymer-based mesh implants are used worldwide to provide tissue reinforcement of the abdominal wall, the pelvic floor or the diaphragm. Our study addresses mesh visualization with positive contrast techniques in MRI and is of interest both to clinicians who wish to assess implant related complications and to researchers who wish to visualize susceptibility induced effects.

Purpose

We have shown that iron-loaded meshes can be visualized by using susceptibility artefacts in gradient echo sequences (GRE). However, this approach suffers from the fact that the abdominal cavity comprises other signal free structures such as air filled bowel, impeding a clear differentiation of susceptibility induced voids from proton deficient voids. Similar problems arise in stem cell imaging which led to the development of different positive contrast techniques. The application of positive contrast susceptibility imaging (PCSI) for mesh visualization has been tested in animals before and helped to achieve a complete delineation of mesh borders. One drawback of PCSI is the necessity for an additional time consuming and complex sequence acquisition protocol. GRE allow for a calculation of susceptibility maps (so called susceptibility gradient mapping (SGM)) in a mere postprocessing step. The aim of this study is the comparison of two positive contrast techniques (PCSI and SGM) for mesh visualization and the assessment of the additional information gained compared to GRE.

Methods

In an approved study, five patients with laparoscopically implanted mesh implants for hernia treatment underwent MRI one day post surgery at an 1.5T scanner (Achieva, Philips) with a 16-channel receiver coil using the following two sequences: 1) conventional GRE: repetition time (TR) 8.3 ms, echo time (TE) 4.6 ms, 2 sample averages (NSA), flip angle (FA) 20°, bandwidth, 215 hertz per pixel, field of view (FOV) 350 mm2; voxel size 0.95 times 0.97 mm2, slice thickness 5 mm and scan duration 2 minutes 26 seconds; 2) PCSI: 3D gradient echo sequence with a selective prepulse to suppress on-resonant water and fat protons. Prepulse flip angle 120°, prepulse duration 5 ms. Imaging sequence: TR 25 ms, TE 4.6 ms, FA 20°, NSA, 8, 3D k-space sampling, scan duration of 7 minutes 28 seconds. A comparison of GRE, PCSI and SGM was done by three experienced radiologists independently evaluating the following criteria in a semiquantitative scoring system: a) visual conspicuity of the mesh, b) differentiation from other abdominal structures c) overall diagnostic value

Results

Images using the three above mentioned methods (GRE, PCSI and SGM) were acquired and showed most reliable mesh differentiation in conventional GRE. The generation of positive contrast of the meshes was feasible both with PCSI and SGM. While PCSI showed good mesh visualization in animals, it proved to be more challenging in humans due to its low CNR and its vulnerability towards movement artifacts. SGM visualized the meshes with a high signal, without the need for an additional sequence acquisition step. CNR and visual conspicuity was higher compared to PCSI.

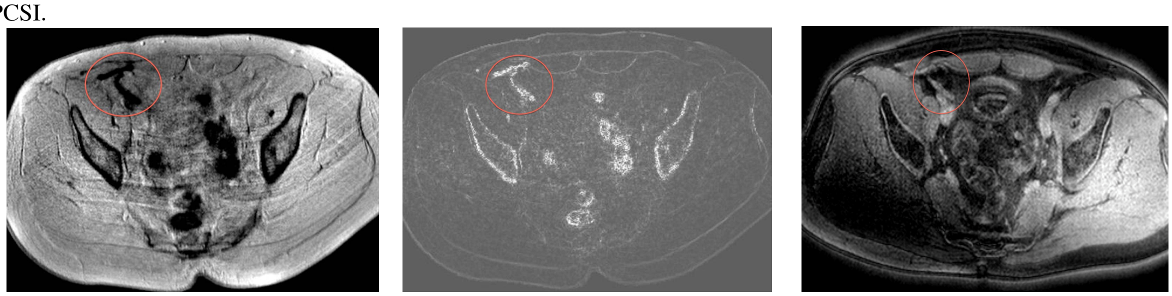

Figure 1: Acquired Images of a patient who received an iron-loaded mesh in the abdominal wall lateral to the rectus abdominis muscle. From left to right: GRE, SGM, PCSI

Discussion

In our comparison we found that SGM delivered better conspicuity and delineation of the mesh against its surroundings compared to PCSI. While PCSI offers good contrast in phantom and animal studies it proved challenging in the clinical setting with human-implanted abdominal meshes. We reason that this is due to the inherently small signal which requires multiple averaging and suffers from slight respiratory induced movement artifacts. Beyond, folding of the meshes leads to a higher effective iron concentration in comparison to the animal studies. SGM shows the mesh with a high signal and require a mere postprocessing step that does not per se prolong measurement time. We found that SGM did not add essential information compared to conventional GRE in our setting. However, since it is a method in which additional information is translated into an image it might help to differentiate the mesh from its surrounding structures under certain circumstances.

Conclusion

We have examined means of visualizing mesh implants in MRI with special emphasis on the comparison between PCSI and SGM. PCSI proved challenging due to its low SNR. SGM is a modality which comes free in terms of measurement time and gave a good signal of the mesh, however the benefits were marginal in our study.

References

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