

## Assessment of Hernia Mesh Shrinkage using Fourier Analysis of Susceptibility Gradients

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### Clinical Relevance statement

Shrinkage of hernia mesh implants often results in medical complications. Using iron-loaded MR-visible mesh implants, the proposed method could help to quantify local mesh shrinkage without additional scan time and excessive post-processing.

### PURPOSE

One of the most frequent surgical procedures worldwide is the surgical treatment of abdominal hernia with textile implants.

Shrinkage and deformation of the implant are notorious causes of mesh-related long-term complications. Because conventional mesh implants are invisible using regular radiological methods, until today, the assessment of mesh shrinkage and migration has been limited to direct observations either in animal studies or in patients undergoing surgical revision due to complaints.

After mesh based hernia repair, one of the most frequent surgical procedures worldwide, shrinkage and deformation of the implant are commonly blamed for long-term complications.

In previous studies, mesh implants for hernia repair were visualized by embedding iron-oxides in the polymer base material. On MRI, the implants exhibit local susceptibility artefacts surrounding the mesh filaments. Dahnke et al. presented an approach to calculate these gradients based on the complex data of GRE sequences [1].

The purpose of this study was to evaluate a method analysing the mesh related susceptibility gradients to assess mesh shrinkage.

### MATERIAL AND METHODS

Three iron oxide-loaded MR-visible mesh implants (DynaMesh visible, FEG Textiltechnik, Aachen, Germany), one in original size and two artificially shrunk to 14 and 48 % were placed in an agarose gel phantom. MRI was performed at a 1.5 Tesla scanner (Achieva, Philips Healthcare, The Netherlands) using a multi-channel coil. The images were acquired in coronal orientation using gradient echo sequences (GRE) [Fig. 2A/2B] [2] (TR=8.8ms; TE= 4.1ms; FA=20°; Matrix Size= 384x380; FOV= 160; scan time =16s; Slice Thickness = 25 mm). Using these GRE image stacks, susceptibility gradient maps were calculated using dedicated software (SGM tool of the "Pride" software environment) [Fig. 3A/3B]. On these maps, a Fourier analysis (FFT) was performed on ten small rectangular areas. This resulted in one frequency spectrum indicating the alternating susceptibility induced magnetic field gradients.

### RESULTS

The spectrum of the original mesh (no shrinkage) revealed one dominating frequency and two harmonics [Fig 4A].

In case of medium shrinkage [Fig. 1-3 B], the spectrum showed a broader bandwidth of frequencies around the dominating frequency which was shifted by 6% to the right. The analysis of the strongly shrunken mesh (not shown in Figure) resulted in an even broader spectrum with an additional increase of the dominating frequencies.

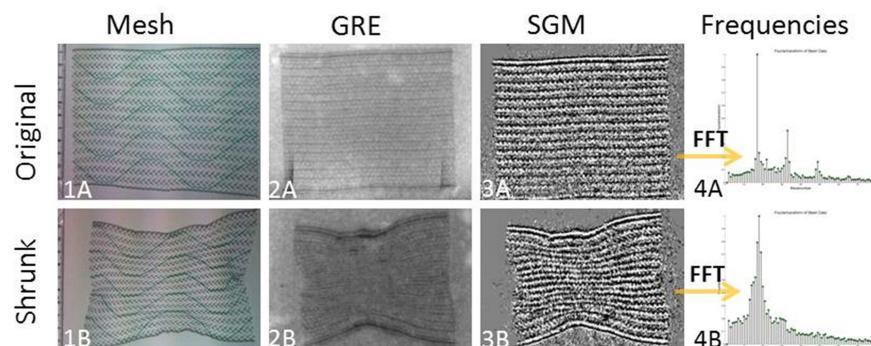


Figure: Two iron loaded mesh implants (1A/1B): original size (upper row); artificially shrunk mesh (lower row); coronal GRE images of the two mesh implants (2A/2B). Susceptibility Gradient Maps (SGM) (3A/3B); The corresponding calculated frequency spectra (4A/4B).

### DISCUSSION

In vivo, the structure of mesh implants can be complex. Thus, the overall assessment of mesh shrinkage is either impossible or demands extensive 3D postprocessing [3]. In this study, the periodical structure of mesh implants is exploited to analyse mesh shrinkage.

The increase of the spatial frequency after shrinkage relates to the convergence of the iron-loaded mesh threads. As shrinkage is not homogenously distributed over the mesh, the singular dominating frequencies derived from the original mesh changes to a broader bandwidth in the shrunk meshes.

### CONCLUSION

In this study, only information from parts of the implant are required to assess the frequencies reflecting the mesh structure, the assessment of local configuration changes is possible if the original mesh structure is known.

### REFERENCES

1. Dahnke et al. Susceptibility Gradient Mapping (SGM): A New Postprocessing Method for Positive Contrast Generation Applied to Superparamagnetic Iron Oxide Particle (SPIO)-Labeled Cells. *Magn Res Med* 2008; 60:595-603.
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