First In-human MR-Visualisation of Surgical Mesh Implants for Inguinal hernia treatment.

Nienke Lynn Hansen[1], Alexandra Barabasch[1], Martina Distelmaier[1], Alexander Ciritsis[1], Nicolas Kuehnert[2], Jens Otto[2], Joachim Conze[2], Christiane K. Kuhl[1], and Nils Andreas Kraemer[1]

[1]Department of Diagnostic and Interventional Radiology, RWTH Aachen University Hospital, Aachen, NRW, Germany, [2]Department of Surgery, RWTH Aachen University Hospital, Aachen, NRW, Germany

TARGET AUDIENCE: Clinical Radiologists and Clinical Scientists

PURPOSE

Surgical treatment of abdominal hernia is one of the most frequently surgical procedures worldwide. Implant deformation is commonly blamed for severe mesh-related long-term complications. Conventional polymere based surgical mesh implants cannot be depicted using conventional radiologic methods including MRI. Consequently, exploratory laparotomy is currently the only reliable diagnostic method. We established an approach to visualize surgical textile implants using MRI (1) (2). Tiny iron particles integrated into the mesh base material induce local susceptibility differences, which can be depicted as signal voids. In previous animal examinations, this approach was demonstrated in in vivo (rats, rabbits and pigs) (3). After clinical approval of this mesh technology, this study was initiated to investigate textile implants in a more anatomically complex, clinical setting in patients treated for inguinal hernia. Purpose of this study was to establish an MRI sequence protocol and to evaluate the immediate post-surgical findings. Therefore, different MRI sequences were compared.

METHODS

Approved by the ethics committee, a prospective study with patients surgically treated for inguinal hernia was performed between March and October 2012. In 13 patients an iron-loaded mesh implant was placed either using a laparoscopic technique (TAPP; n=8) or an open surgical procedure (Lichtenstein surgery; n=5). MRI examinations were performed on day 1 after surgery at a 1.5 Tesla scanner (Achieva, Philips, The Netherlands) with a 16 channel receiver coil using two different gradient echo sequences (GRE) and one turbo spin echo sequence (TSE) (sequence parameters see Tab 1.).

Three radiologists (one, five and ten years of experience in abdominal MRI) independently evaluated the MR images. Conspicuity of the mesh implant with respect to anatomical structures and post-surgical air and the diagnostic value of the referring sequence were rated using a semi-quantitative scoring system (1: insufficient, 2: sufficient, 3: good, 4: optimal, and additionally for diagnostic evaluation 0: not visible). Mesh deformation and localization were visually assessed. Statistical analysis was performed using Wilcoxon signed rank test.

Sequence	TR/TE	flip angle	FoV/matrix
TSE	4372 / 80	90°	360/ 512x348
GRE1	8.3 / 4.3	20°	350/ 368x360
GRE2	244 / 4.6	80°	310/ 336x268

Table 1: Sequence parameters.

RESULTS

In all 13 patients, the implants were successfully visualized by MRI. On GRE sequences, the mesh clearly delineates as a thick hypointense line (Fig. 2b and 2c, arrows), whereas on T2-weighted TSE the mesh was only depicted as a faint hypointense line (Fig 2a, arrow) that was difficult to distinguish from other structures. GRE1 was rated best for visual conspicuity (average score 3.8, $p<0.05$). The TSE sequence was preferred for evaluation of the anatomy (3.8, $p<0.05$). GRE2 was rated best for diagnostic quality of both mesh and anatomy combined (3.5, $p<0.05$). Local air slightly reduced mesh delineation resulting in a still sufficient/good image quality (lowest average rating 2.8) without statistical differences. Overall, the mesh implants in both laparoscopic and open implantation exhibited mild to moderate deformation (2.4 on average with open technique, 2.7 with laparoscopic technique). In 11 of 13 patients, coverage of the hernia was achieved.

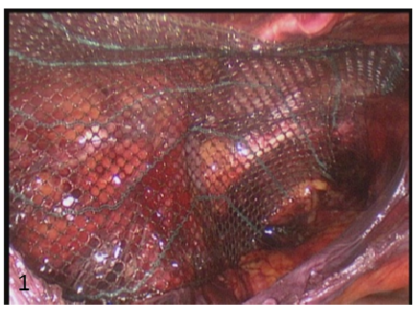

Figure 1: Intraoperative view of the groin and the mesh implant during laparoscopy.

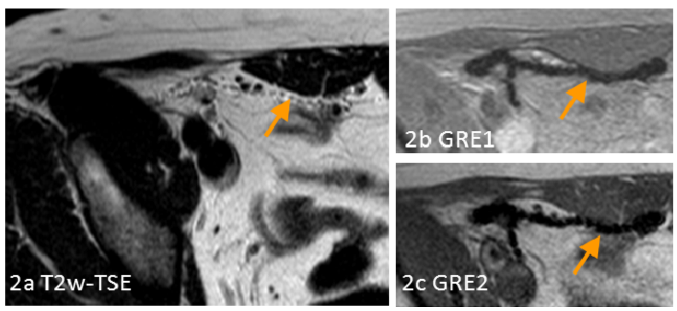

Figure 2: Axial view of a patient's groin. TSE (left), GRE1 (upper right) and GRE2 (lower right) sequences. The arrows indicate the mesh implant.

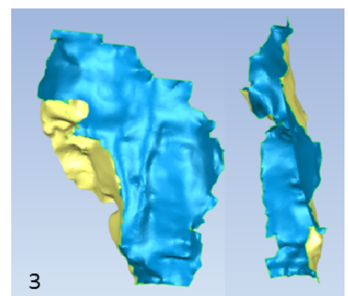

Figure 3: 3D reconstruction of one patient's mesh implant seen from two views.

DISCUSSION

In this study, we achieved mesh visualization using MRI for the first time in human patients. GRE1 best facilitated mesh delineation. However, the surrounding anatomy was not sufficiently depicted. In contrast, TSE was suited best for evaluating the surrounding anatomy, but the mesh was not adequately distinguishable as the refocusing pulses in a TSE sequence suppress the susceptibility differences. To evaluate the surgical success, both, assessment of mesh and anatomy combined, is mandatory. Taking both criteria into account, GRE2 showed the best results but achieved merely adequate ratings in the respective separate categories. Consequently, we propose a combination of the above mentioned sequences to achieve a maximum of diagnostic value.

CONCLUSION

The use of iron-loaded surgical textile implants offers the possibility to visualize mesh location and configuration. MRI could therefore be a non-invasive alternative to surgical revision if mesh-related complications are suspected. For the MRI protocol, we propose a combination of the above mentioned three sequences to properly visualise iron-loaded mesh implants.

REFERENCES

1. Kraemer NA et al. (2009). Development and Positive Contrast Imaging of an MR-Visible Mesh-implant for repair of abdominal hernia. Proc. Intl. Soc. Mag. Reson. Med 17:663.
2. Kraemer NA et al. (2010). A concept for magnetic resonance visualisation of surgical textiale implants. Invest Rad 45(8):477-483.
3. Kuehnert N et al. (2012). In vivo MRI visualization of mesh shrinkage using surgical implants loaded with superparamagnetic iron oxides. Surg Endosc 26(5):1468-75.