3D radial UTE MRI for serial assessment of fibrosis development and silicone implant distortion in rat.

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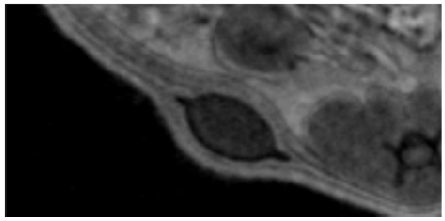
Introduction

The fibrotic reaction, forming a capsule, around implantable medical devices is an important problem as it limits the function of the device, often causing pain and requiring implant substitution. Up to 10-15% of silicone breast implants develop capsular contraction, a condition that requires re-operation due to pain and prosthesis deformation and dislocation. 3D MRI with ultrashort TE techniques is proposed as an early, pre-clinical quantification method and to serially assess the formation of capsular tissue around silicone implants. Results will possibly lead to standardized methods for early detection of excessive capsular formation, decreasing complication rates in affected patients.

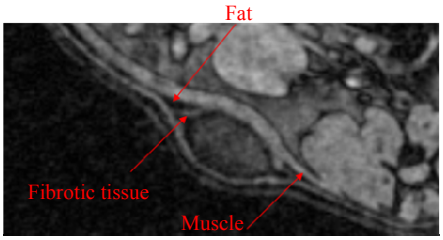
Methods

Two rats were transplanted with up to six 1ml volume implants (n=9) and imaged using 3D radial UTE imaging techniques [1-3]. UTE image on a Siemens MAGNETOM Trio 3T clinical scanner had parameters; a 3D isotropic resolution matrix of 320 and a 12cm FOV, with 35000 radial projections. TE(1)/TE(2)/echo spacing/FA = 0.07ms/5.7ms/9.6ms (x 70-110 segments)/10°. This imaging sequence and reconstruction techniques have been described previously [2]. Respiratory triggering, pausing imaging during the short inhale/exhale period, used a pressure pad and external trigger input system (SA Instruments Inc. Stony Brook NY, USA) with a trigger delay of around 150ms to ensure imaging is at a constant respiratory position over the 6 minute scan time.
The second echo was adjusted to correct for chemical shift effect by in-phase imaging of silicone and/or fat and water. Fat suppression was also applied to help identify layers around the implant. T1 IR and silicone only images were acquired for comparison.
Image analysis included segmentation using Osirix and calculation of sphericity (deviation from a sphere with a value of one) to measure distortion. Sphericity[4] is defined as $\Psi = \frac{\pi^{1/3}(6V_p)^{2/3}}{A_p}$, where V_p is volume and A_p is surface area. Area and perimeter of segmented images were extracted using Matlab (MathWorks Inc.) and used extended over the full 3D volume of each implant to calculate sphericity.

Results and Discussion



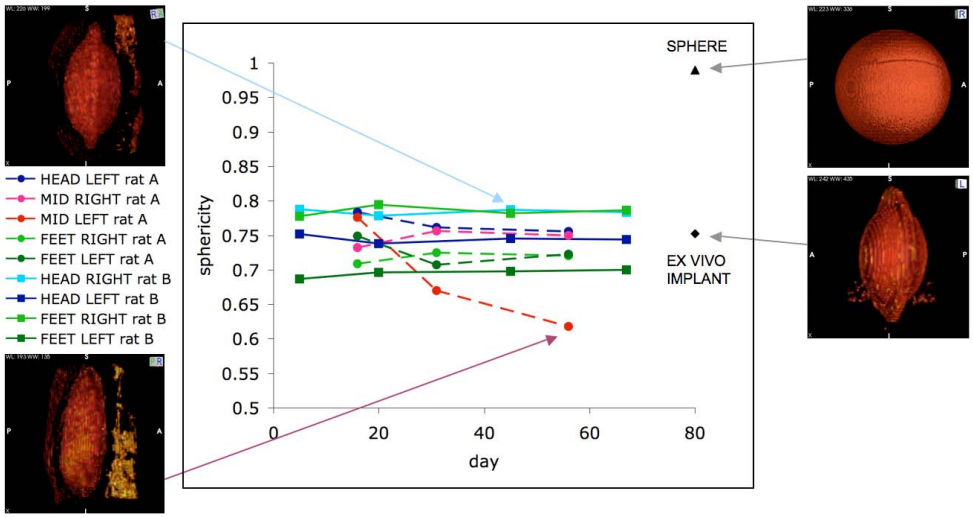
UTE (0.07ms) for segmentation of implant Resolution 0.375mm in-plane and slice thickness



TE2 (5.7ms),with Fat Saturation to identify layers

The layers of fibrotic tissue around the implant can be seen in contrast to the subcutaneous fat, into which the implant is initially implanted.

The UTE image gives an artifact free image with good contrast from all surrounding tissues to facilitate segmentation for shape assessment. A non-distorted implant in a gelatin phantom has a sphericity value of 0.75. In vivo most of the implants show a constant sphericity over time, with some slight changes over the early weeks. One example of an implant that leaked between the first and second scan showed a dramatic change in shape that continued to modify over the time due to displacement of the free liquid silicone. Values obtained in 9 in-vivo implants, a sphere and an ex vivo implant are shown in the plot to the right.



Conclusion

High isotropic resolution images, and multiple contrasts free from motion, wraparound, chemical shift and susceptibility artifacts make the UTE 3D radial sequence promising for the identification of small changes in surrounding tissue and implant shape.

References

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