Development of MR visible mesh for soft tissue reinforcement in surgical treatment of genital prolapse.

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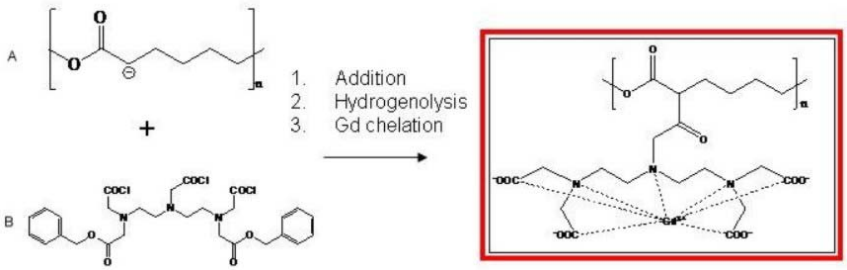
Introduction :

Genital prolapse surgery occurs into 1-3‰ of the female population. Since the late 90's, prostheses may be used for the soft tissue reinforcement. One of the major drawbacks of such meshes is due to their erosion that occurs with time and the lack of efficient imaging technique to follow this erosion and/or motion of the device. As MR imaging is the gold standard for female pelvis imaging, we develop MR visible meshes.

Materials:

Chemistry:

An anionic activation of poly(ε-caprolactone) (PCL) chain is performed by the removal of a proton from the methylene group in alpha-position of the ester carbonyl present in the main chain, using a non-nucleophilic base. The resulting macropolycarbanion (A) can then react with the electrophile group of a modified DTPA molecule (B) that after hydrogenolysis will lead to a biocompatible polymer able to chelate Gd^{3+} ions and therefore becomes detectable using MRI.

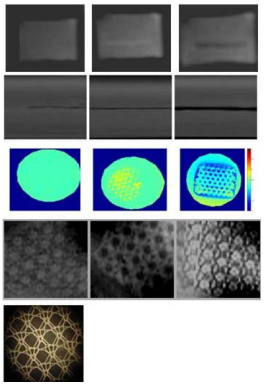


MR:

Relaxivities of the grafted polymer were measured at 0.47T (Bruker, MNS 120) and 7T (Bruker, DRX 300) using either an inversion recovery sequence or a conventional spin echo sequence. Gadolinium was quantified using ICP-MS (Inductively Coupled Plasma Spectrometry Mass). Clinical field MR images of the mesh (Parietex, Covidien) coated with poly(ε-caprolactone)-DTPA ± Gd were performed using a conventional T1-weighted sequence once the meshes were embedded in a 1% type VII agarose gel. High field (7T) MR images of the same meshes were performed using a standard 3D-gradient echo (TR/TE/α=110ms/4ms/20°) and a 3D-FLAIR-type sequence (TR/TE/TI= 2500ms/16ms/1300ms). For quantization and mapping of the susceptibility effects, a new method called SIRMA (SIgnal Response MApping to dephaser) was developed to measure the echo shift in the k-space induced by the susceptibility gradient using a series of positive contrast images collected using incremental slice refocusing gradient offset. Signal intensity profiles are then generated from the set of images and the shift of the maximum of the signal response profile is measured by the SIRMA method to produce susceptibility gradient map as the shifts are proportional to the susceptibility gradients.

Results:

R1 relaxivities for the grafted polymer were measured at R1=17 $mmol^{-1}s^{-1}$ at 0.47T and R1=11 $mmol^{-1}s^{-1}$ at 7T. At 1.5T, the [PCL-DPTA w/o Gd] coated mesh was not visible on the T1-weighted sequence (line1, left) whereas chelation of Gd (~ 3µg/mg PCL-DTPA) allows its depiction (line 1 middle – positive contrast). If quantity of Gd is increased, the image contrast is driven by susceptibility effect (line 1 right – negative contrast). At high field, the same samples mainly displayed the susceptibility effects on the T1-weighted sequences (line 2). The susceptibility effect can be easily mapped and quantified using the SIRMA method (line 3) The Gd-unloaded polymer did not induce any significant susceptibility artefact, whereas the increase in loading leads to the increase in susceptibility.



The use of a 3D-FLAIR-type sequence with a high resolution allows the depiction with a positive contrast of the mesh coated with PCL-DPTA-Gd (line 4 middle) as long as the susceptibility effect do not overpass the T1 effect induced by the chelated Gd (line 4, right). As a comparison, line 5 presents the mesh seen through a binocular

Conclusions:

Coating of commercial meshes using chemically engineered poly(ε-caprolactone)-DTPA-Gd- allows the detection of such device. Coating stability and effect in terms of biocompatibility is under evaluation. This work has been funded by French National Research Agency (ANR) through, TecSan program (project TREBARO n°ANR-08-TECS-20).