Improvement of MR visualization of prosthetic heart valves

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Introduction: The purpose of this project was to improve visualization of prosthetic heart valves (mechanical and biological) under MRI. The stent based heart valves comprises a fresh porcine heart valve that was sutured into a Nitinol stent. The visualization of the heart valves should be improved by using of a resonant circuitry.

Material and Methods: Resonant circuits were designed comprising of a helical coil as inductive component and a non-magnetic SMD-capacitor. The coils were made from enameled copper-wire, then soldered to the capacitor and attached to the heart valves. The stent based heart valve was made of Nitinol – stent (Memothem, Bard Angiomed Karlsruhe D (∅18mm and 70mm long)) and a fresh porcine heart valve. Capacitor and coil were tuned to the MR Larmor frequency of the 1.0 Tesla (Philips 10 NT, Software Release 8.5.1) and 1.5 Tesla MRI (Philips Intera Release 10). The frequency was measured with the RF Analyzer (Wiltron). The resonators were coated with silicon.

A pulmonale and aortic heart valve were excised from a fresh porcine heart of a slaughtered 6 month old pig and sutured with 6-0 prolene into the stent. This stent with the resonant circuit was tested in commercial 1.0 and 1.5 Tesla MRI systems (Philips). The heart valves were placed in 0.9% NaCl-solution at 21° Celsius ambient pressure in a Tupperware container using the standard head coil. Valve function was evaluated by reverse flow. Fast-Field-Echo (FFE), MS, TR=150ms, TE=6ms FOV 110x110 with low Flip angles (FA between 15° and 25°) were applied.

Fig. 1 The pulmonale porcine heart valve in the stent and the resonant circuit on the right side and a mechanical heart valve on the right side

Results: The visualization of the heart valves could be improved. The signal difference of the heart valve and test liquid was significant. The artifacts caused by the stent or the mechanical heart valve could be overcome so that the heart valve could be visualized (Fig.2 and Fig.3).

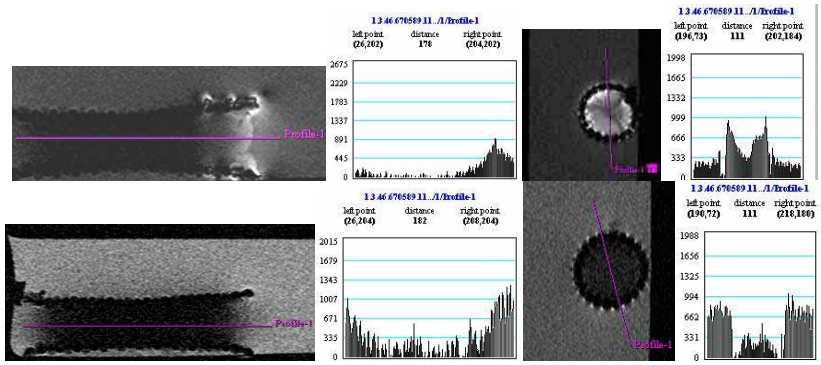

Fig. 2 Heart valve with (above) and without the resonator (1T Philips) FA15°

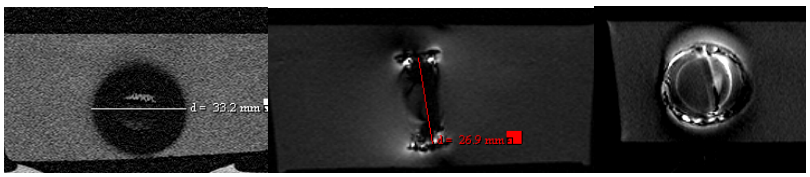

Fig. 3: Mechanical prosthetic heart valve in 1.5 T MRI (FFE, TE6ms, TR50, FA15). The one on the left side without the resonator and the other with the resonator

Conclusion: The results demonstrate that the use of resonant circuit on the stents could minimize the negative shielding effect of the stent structure. This enables the examination of the prosthetic heart valves with MRI and can facilitate MRI guided implantantion.