MR-compatible wireless communication system for the interventional open high-field MRI

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Introduction: To ensure the complication free course of an image-guided intervention, especially in MRI, unobstructed communication between the medical personal and the interventionalist is crucial. A special hurdle to overcome is the high level of noise during image acquisition, which is caused by gradient coils during image acquisition. Verbal communication is thus especially impaired due to the need of ear protection. Communication by means of hand signs is impractical and can only be applied very restrictedly. Technical communication aids have to fulfill high standards for the use in MRI. These criteria can be divided into three categories: MR-compatibility [1], voice quality and manageability. For the successful implementation of a communication system in interventional-radiology, the fulfillment of all of these criteria is necessary.

Materials and Methods: Two prototypes were constructed on the basis of a commercially available ear protection headset (Bilsom 847"MST) and wireless headsets (Logitech ClearChat PC Wireless and Creative HS-1200). To test MR-compatibility, the magnetic attraction was measured with an ASTM F2052 [2] protocol in a Philips 1.5 Tesla GryroScan MRI. The influence of the prototypes on image quality was assessed for interventional purposes in a 1.0 Tesla open MRI (Philips Panorama HFO). Assessment of image quality included the quantification of the change in the signal-to-noise-ratio (SNR) when using the prototypes within the interventional region of interest. We evaluated frequently used interventional sequences such as the T2FSE (TA 1.5 s, FA 90°, TR 1.5 s, TE 0.9 s), T1GRE (TA 2 s, FA 15°, TR 12 ms, TE 7 ms), T2GRE (TA 2.5 s, FA 90°, TR 14 ms, TE 7 ms) and bSSFP (TA 0.8 s, FA 35°, TR 4.6 ms, TE 2.3 ms). To assess the passive sound suppression of the MR-noise, the frequency dependent volume levels each prototype were measured in relation to the unmodified ear protection set. The bSSFP frequency spectrum was recorded in the ear protection capsule five times and then analyzed. Two independent radiologists subjectively evaluated the manageability of each headset during clinical routine.

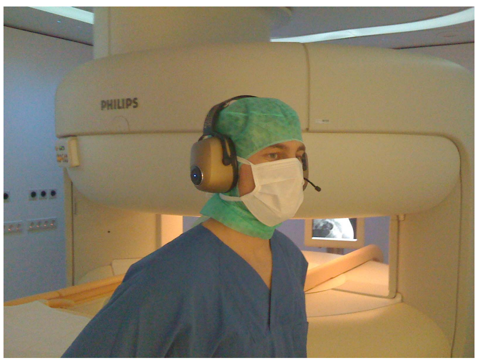

Fig 1: MR compatible headset prototype in clinical use

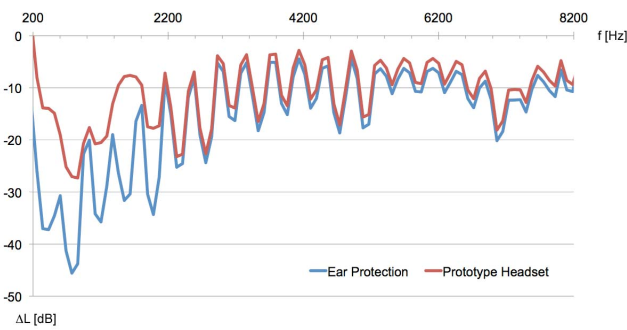

Fig 2: Acoustic damping of the ear protection muffs (blue) versus the Creative HS-1200 prototype headset (red) relative to the frequency spectrum of a bSSFP sequence

Results: The ASTM test to assess magnetic attraction revealed an object deviation of 42° at 2.4 T/m and is therefore below the maximum permitted deviation for MR-compatibility. The weight of the headset is 352 g. In none of the investigated sequences a reduction of SNR could be detected, so that we can preclude a negative influence on image quality. The measurements to assess the quality of speech transmission, showed reduced sound suppression for frequencies of about 10dB. In higher frequency spectrums (over 2000 Hz) the sound suppression behavior of the prototypes was approximately that of the unmodified ear-protection headsets. Two independent users verified the manageability and practicability of the prototypes in the interventional radiology department.

Discussion: Although MR-safety could be established with the ASTM F2052, there remains some interaction between the loudspeakers magnets and the MRI. This interaction however does not impair the transducer of the speakers; moreover only slight torsion was noted. Since the wireless speaker headset is integrated into the ear protection headset, torsion forces are negligible. Therefore, in-ear solutions are less suitable. Both prototypes are based on wireless data transmission technique at a carrier frequency of about 2,4 GHz (Bluetooth) [3] and are thus far away from the mega-hertz range of the MRI-relevant frequency spectrum. The minimal distance between the speaker arm of the headset and the interventional region of interest has to be at least 15 cm due to the horizontally extending artifact that is induced by the prototype. This distance poses no significant restraint to the interventionalists' range of motion. The noise suppression is currently sufficient, but is not acceptable for longer interventions. The construction quality of the prototypes explains this problem. Contact between the speaker and the hard casing of the ear protection capsule could not be avoided. This resulted in reduced suppression of low-frequency oscillations. Moreover, the integrity of the ear-protection capsule could not be completely repaired. The radiologists especially liked the wireless use of the device, the light weight and the easy use without the need for complicated hand signs.

Conclusion: We hereby conclude that the herein presented speech activated communication headset is a practicable and flexible alternative to existing systems.

1. Emanuel Kanal and James Borgstede Et al., American College of Radiology White Paper on MR Safety. Am. J. Roentgenol, 2002, 178: 1335-1347.
2. ASTM Committee F04, Standard Test Method for Measurement of Magnetically Induced Displacement Force on Medical Devices in the Magnetic Resonance Environment, Designation: F 2052 – 06. ASTM International, May 2006.
3. Jennifer Bray and Charles Sturman, Bluetooth: Connect Without Cables. Prentice Hall PTR, 2000.