Construction of a MR Compatible Arthroscopic System and Its Clinical Application

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Introduction: Interventional magnetic resonance imaging (MRI) offers potential advantages over conventional interventional modalities such as X-ray fluoroscopy, ultrasonography, and computed tomography (CT). In particular, it does not use ionizing radiation, can provide high-quality images, and allows acquisition of oblique sections. Current studies have explored feasibility and advantage of usage of MR-guidance in treatment of osteochondral lesions of the knee and ankle joint [1, 2]. Generally, this technique is arthroscopic-supported. Arthroscopy is ideal to give an overview of the surface of the joint cavity. In contrast, MRI is ideal for visualization of tissue under the surface in a cross sectional manner. The combination of both could be an advantage in arthroscopic and endoscopic surgery. In order to increase the availability of MR-guided surgery, an MR compatible endoscopic system was developed.

Material and Methods: In cooperation with the company a MR compatible arthroscope was developed for potential use in MR environment. A commercially available arthrsocope was taken as a model in which ferromagnetic parts were replaced by non-magnetic ones. The safety and practicability within the magnet were carefully examined. This endoscopic system has been examined in 3 cases of arthroscopy-assisted MR-guided meniscus resection in human cadaveric specimen using a titan punch. For real-time MR-guidance, different interactive sequences were tested on their abilities (T1W FSE, T2W FSE, PDW FSE, T1W FFE). Real time MRI and arthroscopic images were displayed simultaneously on two MR-compatible in-room monitors to the surgeons beneath the magnet (interactive PDW FSE: TR: 400ms, TE: 8ms, FOV: 200 x 138, 1.6s/image). All tests and interventions were performed in a 1.0T open MRI (Panorama, Philips, Eindhoven, The Netherlands).

Results: The developed MR-compatible arthroscope was suitable for use in the narrow space of the magnet (Fig 1-4). The safety and practicability within the magnet were found to be very satisfactory; no problems occurred during practical use. In a strong magnetic field it worked properly. The camera system caused acceptable electromagnetic noises in MRI, but they were not considered serious. The interactive PDW FSE sequence was proven to be superior for arthroscopy-assisted MR-guided surgery. All anatomic structures could be visualized arthroscopically as well by MR imaging.

Conclusion: Arthroscopic surgery is feasible under intraoperative MRI image-guidance using a newly MRI-compatible arthroscope. The combination of surface information provided by the endoscope and the in depth information from MRI was found to be very useful in increasing the safety, reliability, and availability of MR-guided intervention therapy, i.e. in cruciate ligament reconstruction or drilling procedures.

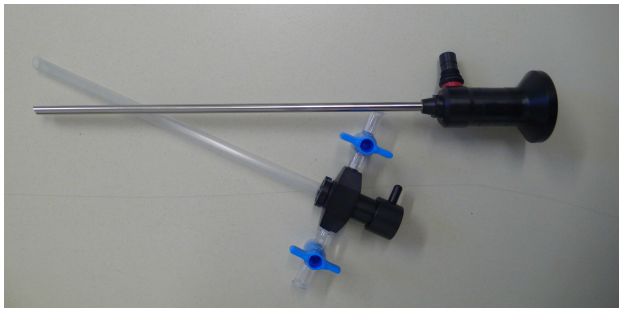

Figure 1. MR-compatible arthroscope; Telescope 30°, 6 mm, with arthroscope sheath.

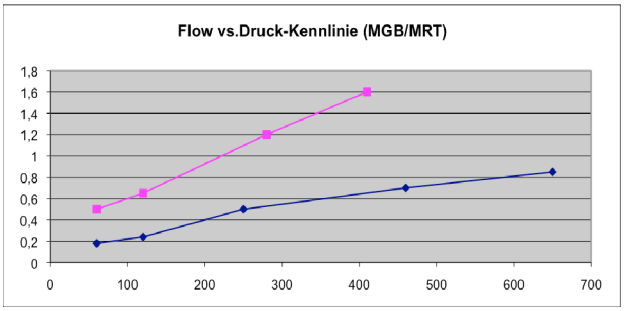

Figure 2. Diagram shows flow measurements of the MR-compatible (blue) and the commercially available arthrsocope (red). It is shown that flow values of the MR-compatible arthroscope are better than of the commercially available arthrsocope.

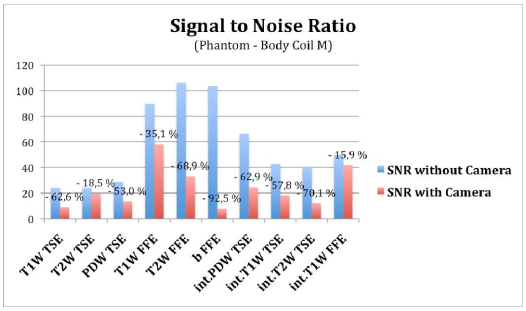

Figure 3. Figure shows the decrease of the signal-to-noise ratio under usage of the arthroscope and camera system.

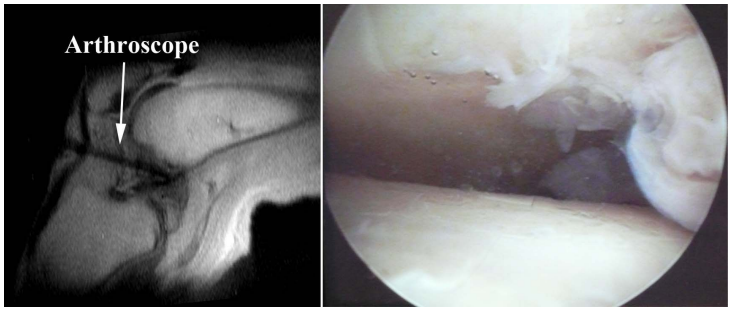

Figure 4. Figure shows sagittal int. PDW FSE image (TE: 8 ms, TR:400 ms) and arthroscopic view using the developed MR-compatible arthroscope during interactive MR image acquisition. Anatomical structures could be distinguished simultaneously by MR and arthroscopy.

References

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