High resolution ex-vivo imaging of a rodent kidney with a portable MR-Scanner at 0.5 Tesla: Initial results in relation to state of the art techniques

Florian Lietzmann[1], Christina Hopfgarten[1], Jorge Chacón-Caldera[1], Stefania Geraci[2], and Lothar R. Schad[1]
[1]*Computer Assisted Clinical Medicine, Heidelberg University, Mannheim, Germany,* [2]*Medical Research Center, Heidelberg University, Mannheim, Germany*

Introduction

Filtration processes in the kidney are fundamental for the clearance of waste products from the metabolism. A renal impairment can quickly lead to a malfunctioning blood pressure and adrenal hormone regulation or even uremia with the eventual need of dialysis or transplantation. The European cooperation Eurotransplant, including eight countries, counted 3299 performed kidney transplants in the year 2011 [1]. Looking at any waiting list for kidney transplantation, the need for an early diagnosis to avoid transplantations becomes obvious. Therefore, alternative diagnostic modalities that allow to the detection of even slight morphological or anatomical renal changes gain further importance. To improve the understanding of the relevant processes in the kidney it is important to have a thorough knowledge of the kidney's basic composition, making high-resolution MR imaging indispensable. Nowadays high-resolution images are acquired either with high-field animal scanners or a special coil setup for human whole body systems. Hence, renal imaging using MRI is crucial but not available to many institutions because until now it relied in high-end systems working at high or ultra high field strengths. As an alternative, a low-field portable MR-system which can achieve similar resolutions like a small animal system can provide such images. This work is presents initial results of the acquisition with the portable system at 0.5 T in relation to state of the art methods.

Materials and Methods

Images were acquired with **A/B:** a 0.5 T portable MR system "portable^{Lab}" (Pure Devices, Würzburg, Germany), **C:** a human whole-body 3 T Skyra (Siemens Healthcare, Erlangen Germany) using a 8-channel rat volumetric resonator (RAPID Biomedical, Wuerzburg, Germany) and **D:** a 9.4 T small animal scanner Bruker BioSpec 94/20USR (Bruker BioSpin GmbH, Ettlingen, Germany) using a cryogenic surface coil (CryoProbe). For the measurements with the 0.5 T and the 9.4 T systems, mouse kidneys were embedded in agarose gel. For the measurements with the 3 T system a rat kidney was prepared in the same way. Data were acquired with parameters as follows:

A 2D Spin Echo: TE/TR = 5/400 ms, MTX = 64 x 64, FOV = (9 mm)², slice thickness = 1 mm, resolution = 140 µm x 140 µm in plane AVG = 300, TA = 4h15m.
B 3D FLASH: θ ≈ 51°, TE/TR = 15/46 ms, MTX = 128 x 128 x 128, FOV = (1.28 cm)³, resolution = 100 µm isotropic, AVG = 80, TA = 67h.
C 3D FLASH: TE/TR = 60/100 ms MTX = 160 x 100 x 48 (zero-filled to 96), FOV = 2 x 3.2 x 1.9 mm³, resolution = (200 x 200 x 400) µm³, AVG = 32, TA = 3h20m.
D 3D TrueFISP: TE/TR = 4/8 ms, MTX = 200 x 240 x 256, FOV = (1.2 x 1 x 1.5)cm³, resolution = 50 µm isotropic, TA = 6m.

Results & Discussion

Fig. 1 shows images of mouse and rat kidney acquired with the different methods described above. In all images a distinction between the different tissue compartments (cortex, outer medulla, inner medulla, collecting system) is possible. Additionally an inner structure is visible in the cortex in the image with a resolution of 140 µm (A) which gets more pronounced in the image with a resolution of 100 µm (B). The images acquired with a human whole body MR-system (C) are not sufficient to determine any inner structure of the renal cortex. The highest resolution could be achieved with the small animal scanner at 9.4 T (D). The drawback of this method is the use of a cryogenic surface coil which results in a gradient in signal intensity (from left to right). This might become a problem in the use of quantitative methods. Even with its low field and with that its low signal, the portable MR system provides a high resolution and sufficient image quality for in vitro studies of mouse kidney. An objective comparison between a portable 0.5 T, a clinical 3 T scanner and a preclinical 9.4 T is not possible due to the extremely different capacities and purposes. The images presented are just to show how features in the kidney can be imaged in a preclinical 9.4 T, clinical 3 T and even a portable 0.5 T.

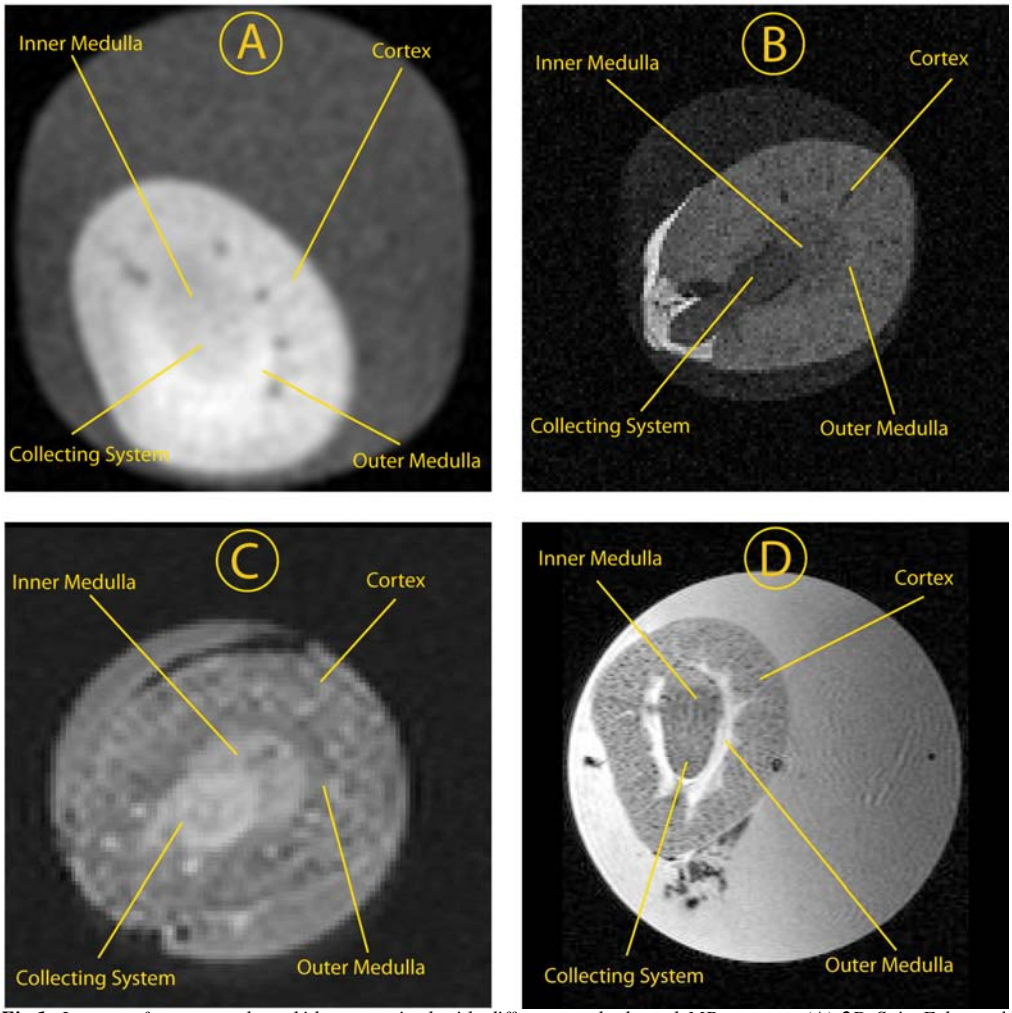

Fig.1. *Images of mouse and rat kidney acquired with different methods and MR systems. (A) 2D Spin Echo and (B)3D FLASH images of mouse kidney acquired with 0.5 T portable MR system, (C)3D FLASH image acquired with human whole-body 3 T scanner and (D)3D TrueFISP image acquired with a 9.4 T small animal scanner.*

Conclusion

High resolution imaging of the kidney need not necessarily be performed on high field systems. The portable MR system reaches a sufficient resolution for the distinction of different renal compartments as well as the identification of an inner structure of the renal cortex. Even though the measurement time is relatively long, the advantages of using such a system are unambiguous. Because of the all-time availability of the portable system, there is no need to block clinical systems for ex vivo measurements. Additionally it provides a cost efficient solution to produce high-resolution images with an image quality comparable to systems with higher field strengths and thus can make research in kidney imaging more widely available. Beyond renal imaging the system also might prove useful for other applications requiring high resolution like cellular imaging [2].

References

[1] Eurotransplant (2011). International foundation: Annual report 2011. Edited by Arie Oosterleeand Axel Rahmel
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