Real Time Passive Motion of the Musculoskeletal System - Using a Motor Driven Kinematic Device During Ultra Fast MRI

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Summary

We have developed a motor driven kinematic device which enables pre determined motions of several joints during real-time MRI and a suppression-interference-system to avoid artifacts during motor action Twenty-one volunteers underwent MRI examination during passive motion of different joints. Using the device and the suppression-interference-system we were able to obtain passive motion of joints visualized artifact free and in detail with ultra fast MRI.

Introduction:

It was our purpose to develop a MR-compatible motor driven kinematic device and obtain distinct predetermined motions of several joints in real time MR imaging in order to enhance the diagnostic potentiality for the musculoskeletal system.

Ultra fast MR imaging is becoming increasingly valuable since the development of modern MRI scanners. For the diagnosis of the musculoskeletal system besides static imaging, functional imaging like stress MRI, cine MRI and real time MRI have been applied. So far, only real time MR examinations of active motions of the musculoskeletal system have been described. To obtain passive and predetermined motions of any body joint in real time MR imaging, we have developed a custom made MR-compatible motor driven kinematic device and a suppression-interference-system to avoid artifacts during motor action. The examination of passive motion of the joints will potentially be advantageous and more valid to depict pathologies of the musculoskeletal system, which cannot be detected with static MR imaging.

Material/Method:

A totally MR-compatible kinematic device with two separately motor driven axes was inserted inside the scanner and was remote-controlled by the examiner from outside the MR suite. A suppression-interference-system was developed to avoid artifacts. Twenty-one volunteers (age range 18-39 years) underwent MR imaging. One part of the body (foot, ankle, cervical spine, hand, wrist) was adjusted to the device and was examined during joint motion. MR imaging was performed on a 1.5T unit (Magnetom Sonata, Siemens) using loop or flex coils. TurboFLASH and TrueFISP sequences were acquired using a spatial resolution of 256x256 and a temporal resolution of 300 milliseconds per frame in a total acquisition time of 5 to 30 seconds.

Results:

Motion of joints, tendons, ligaments, and muscles could be well illustrated with ultra fast MR imaging in real time. TurboFLASH sequences were superior to the TrueFISP sequences, which showed concentric stripe artifacts in imaging. No artifacts were caused from the device and the motors when using during imaging.

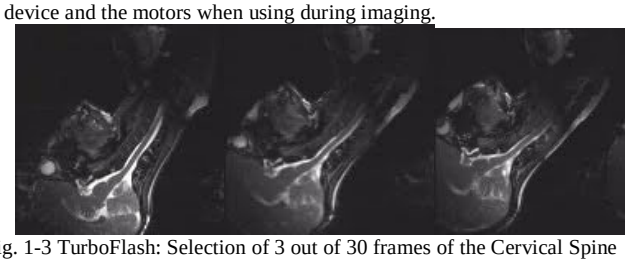

Fig. 1-3 TurboFlash: Selection of 3 out of 30 frames of the Cervical Spine Passive Motion of the Cervical Spine could be depict artifact free in detail

Fig.5 Kinematic Device – Flex Coil Patient Positioning Cervical Spine

Fig. 4-6 TurboFlash: Selection of out of 40 frames of the Ankle Passive Motion of the Ankle could be depict artifact free in detail

Fig.7 Kinematic Device – Loop Coils Patient Positioning Ankle

Conclusion:

Using the kinematic device and the suppression-interference-system it is feasible to obtain artifact free passive motion during ultra fast MR imaging. This method is an excellent diagnostic tool to depict further biomechanical and patho-kinematic conditions of the musculoskeletal system, in particular to distinguish between joint laxities and joint instabilities.