Dynamic 4-Dimensional MRI of Knee Joint Movement Using FLASH 3D VIBE

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Abstract

The purpose of this study was to develop a technique for dynamic 4-dimensional magnetic resonance imaging (MRI) of joint motion based on a combination of FLASH 3D VIBE (Fast Low Angle SHot 3D Volumetric Interpolated Breath-hold Examination) imaging with surface radiofrequency (RF) coil. Using a closed-bore whole body MR scanner, dynamic 3-dimensional imagings of the knee joints were performed with changing the sequences. Addition to the basic technique of FLASH 3D VIBE, applying iPAT (integrated Parallel Acquisition Technique) GRAPPA (SMASH) technique and regulating detail sequences such as band width, TR, Slice thickness and FOV that enabled to take all images of knee joints in full range of motion made it possible to reduce the time required for imaging each whole volume data to 0.7second with appropriate qualities of image. Therefore, this method enabled to take dynamic 4-dimensional images of knee joints and expected to give the useful information for assess the joint abnormalities that express under dynamic conditions.

Introduction

Dynamic magnetic resonance imaging (MRI) techniques are useful for evaluating the joint movement under dynamic condition and sometimes provide important diagnostic information of joint abnormalities and malformation. Although many of these techniques have been developed, most of them are 2-dimensional image examinations. As abnormal joint dynamic motion usually happens in 3-dimensionaly, taking a series of dynamic 3-dimensional images in a short time is ideal for evaluating such condition.

Methods

Five volunteers with clinically normal knee joints and one with medial meniscus horizontal tear on posterior horn in his left knee joint were imaged at side position. A 1.5 Tesla Siemens Sonata system equipped with high performance gradients (40mT/m maximum amplitude, 200 mT/m/msec slew rate) was used to generate the images. Every volunteer lay on the table of MR scanner at side position with the targeted knee joint placed under another one and positioned the anterior of knee joint close to the inner side wall of gantry as he could move his knee joint in full range of motion. Large flexible surface radiofrequency (RF) receive coil was fitted on the knee joint loosely not to interrupt the motion of knee joint. Dynamic 3-dimensional imagines of the knee joints were performed continuously from extension to 120 degrees flexion with changing the sequences based on the technique of FLASH 3D VIBE.

Results

With the technique of FLASH 3D VIBE, it took 2 seconds for imaging each whole volume data of knee joint. Applying iPAT GRAPPA technique to this, the time required for imaging was reduced to 1.2 second and additional regulation of detail sequences made it possible to reduce this time to 0.7second with keeping appropriate qualities of image. The imaging sequence of this was as follows. TR/TE 2.23/1.26 msec, flip angle 12 deg, field of view (FOV) 330*330 mm, slice thickness 4.5mm, bandwidth 1400 Hz/Pix, image matrix 64*256 , voxel 3.9*1.3*4.5, measurements 30 and scan time of 1volume 0.7s. Using this sequence, abnormal motion of torn medial meniscus was easily examined in a short time and observed only to choose the adequate cross section from the whole volume data (Figs .1, 2, 3)

Discussion

Many investigators have been developing dynamic MRI of joints. Harald H. Quick et al. developed real-time MRI of joint movement with true FISP (1). Although this method was useful for assess the abnormal motion of joints, it could not assess 3-dimensional motion as it was 2-dimensioal examination. Andrea J. Rebmann et al. showed the possibility of cine-Phase contrast (PC) MRI techniques as 3D kinematics MRI (2). But they also recognized the necessity to shorten the imaging time. With the sequence of this study, it became possible to take a series of dynamic 3-dimensional images of knee joint in a short time as if taking dynamic 4-dimensional images. Further improvement of this technique will provide us a better understanding of the joint abnormalities that express under dynamic conditions

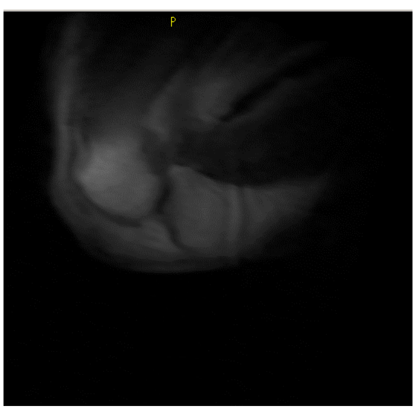

Fig .1 starting

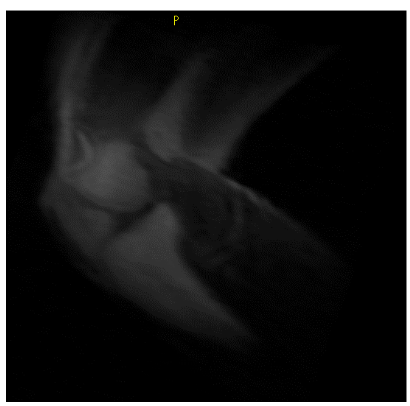

Fig .2 After 2.8s

Fig.3 After 5.6s

References

1. Harald H. Quick, MSc et al. J Magn Reson Imaging 2002; 15:710-715.
2. Andrea J. Rebmann, MBE et al. J Magn Reson Imaging 2003; 17:206-213