Feasibility of MR guided direct arthrography

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Introduction

Direct MR arthrography is increasingly the preferred imaging investigation for diagnosing subtle intra-articular joint pathology, such as labral tears in the shoulder and hip. Current techniques require X-ray fluoroscopic guidance for initial joint puncture and introduction of contrast medium, followed by transfer to an MR system and subsequent joint imaging. The disadvantages of this approach include use. A technique that allows the procedure to be entirely carried out using an MR system would overcome the disadvantage of needing two adjacent radiology facilities and using ionising radiation. This has been previously described using low field strength open systems [1,2] and on a 1T closed system with in room display [3] but not using 1.5T whole body closed bore MRI systems that make up the majority of the installed base used for musculoskeletal imaging worldwide. These "closed" systems in general provide higher performance for both fast and high spatial resolution musculoskeletal imaging. This work develops a method using animal joint simulations and demonstrates the feasibility of performing the initial needle placement and contrast medium injection on a standard commercial 1.5T MR system using in room scanner control and display, with adaptations that are simple to implement, that allows a direct arthrogram to take place in a single MR examination.

Methods

A strategy was developed based on in-room direct control of the MR system and the current approaches used for CT & X-ray fluoroscopic interventions i.e. to confirm the position of the target and needle using interval imaging but to modify the needle position and perform the injection with the patient just outside the bore on the couch. Interactive MR fluoroscopy (IMRF) with a range of susceptibility contrast would allow needle location demonstration: T2w or T2/T1w contrast for observing the injection of lignocaine and T1w imaging for demonstrating the dilute gadolinium used in the joint injection phase. The ability to use thick section "projection" imaging to monitor contrast medium dispersal during the injection phase was also considered desirable.

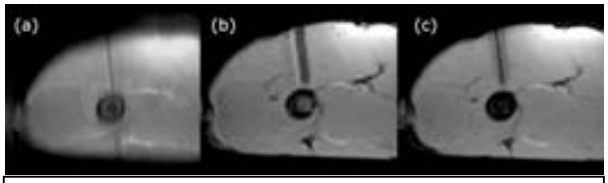

Fig 1: MR-Eye needle artefacts when positioned against a lamb femur using interactive (a) SSFSE, (b) GRE, (c) FIESTA.

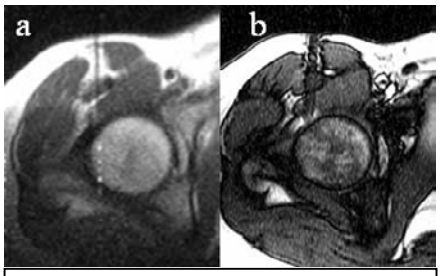

Fig 2: Confirmation of the intra-articular position of the MR-Eye 18G needle in the right hip joint (a) SSFSE, (b) GRE

In room control and display of a standard 1.5T MRI system (Excite HD, GEHT, Milwaukee) was achieved using VNC (version x11, RealVNC, Cambridge, UK), and a standard PC (GX-280, Dell Inc) running Windows XP. The keyboard, mouse, LCD flat panel and related cables were placed inside the scan room adjacent to the couch with the cables fed via a waveguide to the PC system box positioned outside the RF cage. *IMRF* with a range of soft tissue contrast performance was provided using the commercial iDrive interface (GEHT) and the standard GRE (TR 8.5, TE 2.3/fr, matrix 512x192, FOV 30x30, RBW 31.2KHz, frame rate 0.6fpsec. 0.25fps with fatsat) sequence. An inner volume SSFSE (TR 479, Eff TE 58.6, matrix 256x256, FOV 30x18, RBW 125KHz, frame rate 2fpsec) and FIESTA (TR 4.7, TE 1.3/fr, flip 60 degrees, matrix 288x192, FOV 31x31, RBW 125KHz, frame rate 1fpsec) sequence were modified to operate using i/Drive [4] which allows "on-the-fly" modification of image plane location, section thickness, FOV and switching of phase and frequency direction - particularly relevant for demonstrating needle related artefacts [5]. Location "bookmarking" allows rapid switching between these three sequences at a desired image location. *Examination technique* employed a cardiac phased array receiver coil with the open component anterior to the target joint. Using standard FIESTA imaging and the MR coordinate system the skin immediately anterior to the selected site of joint puncture was marked using ink and an oil capsule marker. This was confirmed using the real-time system and following surface anaesthesia with 1% lignocaine an MR compatible needle (COOK MR-Eye 18G Turner Biopsy Needle) was advanced posteriorly in stages until adjacent to the expected location of the joint capsule and this was confirmed after each position change with IMRF. Having confirmed the correct needle position a few mls of the dilute gadolinium (2mls gadopentate dimeglumine (Magnevist, Schering, DE)/litre N saline) was introduced and then imaging repeated to confirm the intra-articular location and the remaining 10-15mls contrast medium was then introduce. After this the MR arthrography sequences performed following the standard institutional protocol. *Ex-vivo simulations* were performed initially using lamb and porcine joints to assess the contrast performance for skin marker, needle, local anaesthetic and contrast medium visualisation in relation to adjacent muscle, fat and other soft tissues. *Patient studies* were performed after individual informed consent and Local Ethical committee approval was obtained for a 12 patient pilot study. Evaluation criteria included success or failure of joint puncture, number of needle passes, degree of extravasation and duration for the contrast medium introduction.

Results

The simulation studies confirmed the value of the range of image contrast (Figure 1) and the ability to rapidly locate and position the needle in the correct orientation relative to the joint. Currently one patient has been examined with this technique: a 33 year old female patient underwent direct MR hip arthrography. The procedure was successful, required a single needle pass with no extravasation and diagnostic quality MR arthrography images were obtained. The IMRF images allowed for rapid needle identification and localisation (Figure 2). The projection fat suppressed GRE imaging allowed simple confirmation of the intra-articular dispersion of the contrast medium (figure 3).

Conclusions

This work demonstrates the feasibility of performing direct MR arthrography using an "all-in-one" single MR examination on a commercial 1.5T closed bore MRI system, avoiding the need for X-ray fluoroscopy facilities but exploiting the available imaging performance of a standard MR system. The use of an in room control and display system simplifies the positioning of the needle and allows rapid confirmation of an intra-articular injection. Further patient studies will be performed as a part of this feasibility study to refine the technique.

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References

1 Petersilge CA et al Am J Roentgenol 1997 Nov;169(5):1453-7.
2 Hilfiker PR et al Eur Radiol 1999;9:201-204.
3 Trattnig S et al AJR 1999;172:1572-1574.
4 Makki et al JMRI 2002:16;85-93.
5 Butts K et al, JMRI 1999;9:586-595.

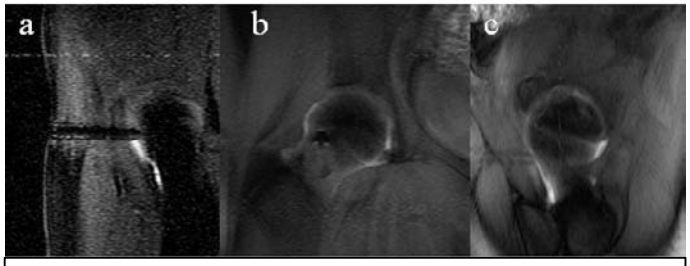

Fig 3: Introduction of contrast medium using fat suppressed GRE (a) 10mm thick section, (b) & (c) 40mm thick "projection" images.