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TECHNICAL REPORT

Modified technique for imaging the wrist and elbow in obese and claustrophobic patients using a non-open standard MRI scanner

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Abstract

Objective It is challenging to image extremely obese and claustrophobic patients using a standard, non-open, magnetic resonance imaging (MRI) scanner. On the other hand, installing an additional upright or open MRI scanner may not be cost-effective for most practices. Our technique with a patient in a sitting or standing position behind the standard MRI scanner may be helpful in the MR examination of the wrist/elbow in these patients using a standard wrist/elbow coil.

Material and methods We performed wrist and elbow MRI of extremely obese and claustrophobic patients by using our modified technique with the patient sitting or standing outside the standard non-open MRI scanner. A total number of 20 cases with the following diagnosis were examined: triquetral and scaphoid bone contusions and fractures, scapholunate ligament tears, triangular fibrocartilage complex tear, and biceps tear.

Results Comparison of image quality for diagnostic information between the standard technique and our technique showed no significant difference, which is necessary for making the diagnosis.

Conclusions Our technique enables wrist and elbow imaging of extremely obese and claustrophobic patients who cannot otherwise be imaged using a standard MRI scanner without compromising the image quality that is essential for making a diagnosis.

Keywords Claustrophobia · MRI · Wrist · Obesity · Sitting · Safety

Introduction

Claustrophobic patients get frightened and experience the feeling of being enclosed in conventional MR scanners, with an average of 2.3% of all patients who undergo an MR examination suffering from claustrophobia. These patients require either sedation to complete the scan or premature termination of the study, which reduces workflow, increases scanning time, and adds to the financial burden [1, 2]. When a patient has an extremely high body mass index or is claustrophobic, there are limited options, which include using an upright or open MRI machine. If the patient is claustrophobic, the imaging team can discuss with the referring clinician whether other available imaging modalities (e.g., ultrasound) can be of help in that particular clinical situation for treatment planning. But most of the time, MRI is the imaging modality of choice in specific clinical situations. An open MRI scanner is the most practical option, but it is not always cost-effective for most of the imaging centers to have an open MRI scanner, and it may not be available everywhere. Also, an open MRI scanner usually has a low magnetic field strength (e.g., 0.35 T) and does not produce very good quality images, which is important for the imaging of small joints; the use of a non-open bore MRI scanner is more desirable (e.g., 3 T). Thus, we have performed an observational retrospective study to evaluate whether a

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modified technique of the wrist and elbow examination on the non-open standard MR scanner provides similar diagnostic results in claustrophobic and obese patients compared with the standard technique.

Materials and methods

This study was performed at Advanced Radiology Consultants (ARC) outpatient offices and was approved by the institutional review board. Written informed consent was obtained from all the patients. We performed the MRI examinations of the wrist and elbow of extremely obese and claustrophobic patients who cannot otherwise be imaged using a standard MRI scanner. We used the standard non-open MRI scanner (Siemens Magnetom Espree 1.5 T, Erlangen, Germany). The same standard wrist and elbow coils and protocols were used as those used in the conventional technique. The MRI wrist protocol included sagittal and coronal localizers, axial proton-density-weighted, axial fat-saturated T2-weighted, coronal T1 fast spin echo (FSE), coronal short tau inversion recovery (STIR), coronal gradient echo (GRE), and sagittal T1-weighted FSE, and the MRI elbow protocol included sagittal and coronal localizers, sagittal T1 FSE, sagittal GRE, axial fat-saturated T2-weighted, coronal STIR, axial T1-weighted FSE, and coronal T1-weighted FSE. Our magnet has a bore length of 125 cm (49.2″) and the patient is centered to the wrist/elbow coil and then centered to the magnet's isocenter. If the patient is very large, there can be a little offset; however, the diagnostic image quality is not affected. If the patient is too short, then the patient is unable to sit for their wrist scan. In this case, the patient can stand or they can stand with one knee on a chair. It is also possible for the patient to kneel on a chair reaching into the scanner. These positions are much easier on the patient than head-first supine (superman position). This standing technique would be impossible to do on an elbow in the longer bore scanners. A wrist may be possible in longer bore magnets if the patient has very long arms; however, motion may be a limiting factor. This technique most likely does not work in scanners in which the wrist coil is built into the side of the table.

A total of 20 patients with the following diagnosis were examined: triquetral and scaphoid bone contusions and fractures, scapholunate ligament tears, triangular fibrocartilage complex tear, and biceps tear. We used the modified technique of MRI in the patients in a sitting position behind a standard non-open clinical MRI scanner with the anatomy of interest placed in the magnetic field (Figs. 1 and 2). MRI-compatible stools and chairs with adjustable heights were used for patients with different heights and arm rests and pads were used to make the patient as comfortable as possible to reduce the movement and thus motion artifacts (Fig. 2). We used an all-wooden stool for this purpose. Because we did not require a new scanner or coils, there was no additional cost. Image quality was also good because of the use of a high magnetic field strength regular MRI scanner. The findings of these patients were compared with those with a similar diagnosis, examined on the same scanner using the standard technique.

Results

Total wrist scan time for this protocol was 18 min and 29 s and for elbow MRI, it was 11 min and 4 s, which was the same as the standard protocol. We have used this scanning approach successfully in many patients with no failures.

Cases

Wrist

Normal anatomy of the wrist is shown in Fig. 3.

A triangular fibrocartilage complex (TFCC) tear is shown in Fig. 4.

Triquetral and scaphoid fractures are shown in Fig. 5.

Triquetral and scaphoid bone contusions with marrow edema are shown in Fig. 6.

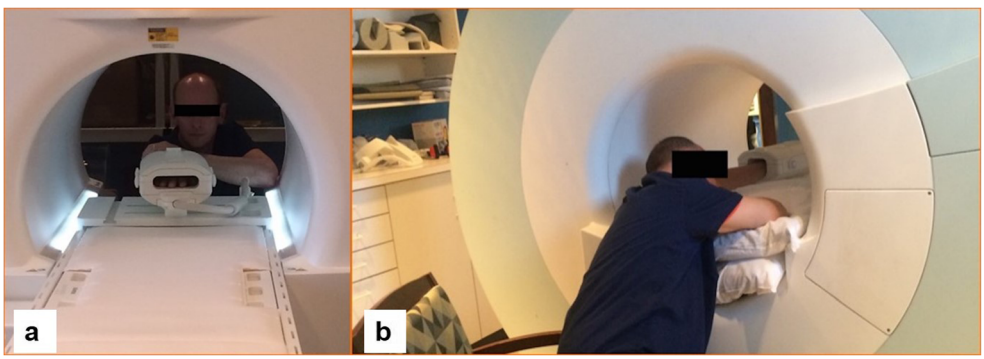

Fig. 1 Patient positioning for wrist MRI while sitting on the other side of the magnet, as seen from **a** the front view and **b** the back view through the bore of the MRI scanner. An all-wooden chair can be used. Please note that a pillow can be used under the other arm for better comfort, which decreases the chance of involuntary motion

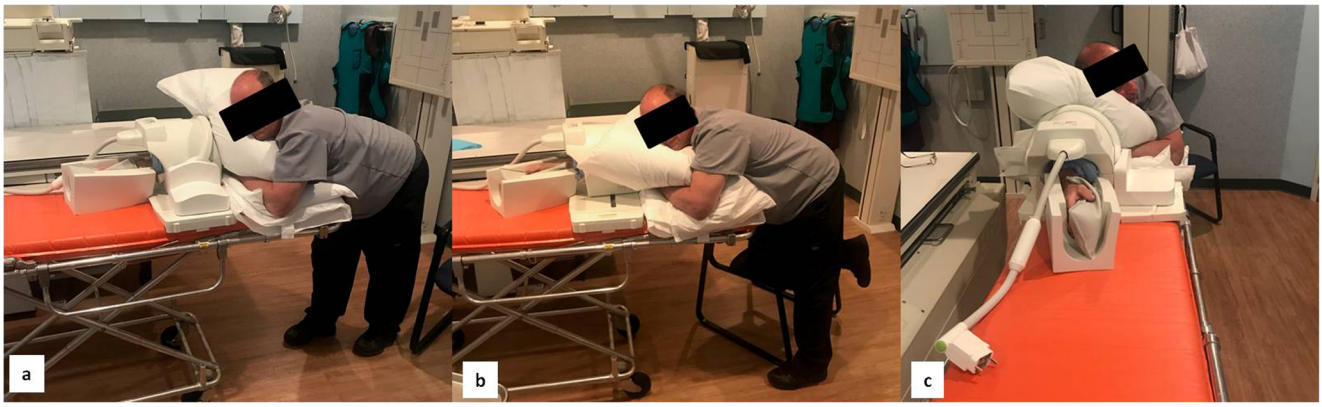

Fig. 2 Patient positioning for elbow MRI. **a** In patients with long arms, the scan can be done while standing, whereas **b** in patients with short arms, the scan can be done with one knee bent and supported by a chair. Image from the other side of the table showing the positioning of the elbow in the elbow coil. Please note that some extra pillows or cushions under the patient's head and other arm make the patient comfortable and eliminate involuntary motion

Scapholunate ligament tears are shown in Figs. 7 and 8.

Elbow

A complete biceps tendon tear is shown in Fig. 9.

Discussion

Magnetic resonance imaging has become the modality of choice in routine clinical practice and the patient's cooperation is required to obtain the best-quality images. The closed bore of a standard MRI machine creates anxiety-related symptoms and claustrophobia. Claustrophobia frightens the patient, thus preventing MR examination in 1–15% of all patients scheduled for MRI. which unnecessarily prolongs the scanning time, reduces workflow, and degrades the image quality. Alternatively, premature termination of the scan unnecessarily adds up a financial loss to the health care system. These types of patients require sedation and additional sequences to complete the examination, which added significant risks of sedation and additional costs for the patients [1–4]. Obesity is another major limiting factor for the MRI scanning of patients with a high body mass index owing to bore diameter and table weight limits, which are usually 60 cm and 159 kg respectively. Because of these limitations, many patients cannot undergo conventional MRI and are referred for upright or open MRI, which has a larger bore diameter and a higher table weight limit [5, 6].

Several measures have been taken to improve patient comfort and avoid claustrophobia reactions by improving the MR design such as open vertical scanner configuration, although

Fig. 3 Our technique: a 53-year-old claustrophobic woman with a normal scapholunate ligament (*smaller arrow*) and a normal triangular fibrocartilage complex (TFCC; *larger arrow*) on a coronal gradient echo (GRE) image. The image quality was comparable with that performed using the standard technique

Fig. 4 Our technique: a 50-year-old claustrophobic man with a TFCC tear (*arrow*) on a coronal GRE image. The image quality was comparable with that obtained using a standard technique

Fig. 5 Our technique: a 30-year-old claustrophobic woman with a triquetral fracture (*arrow*) on a sagittal T1-weighted image of the wrist. The image quality was comparable with that obtained using the standard technique

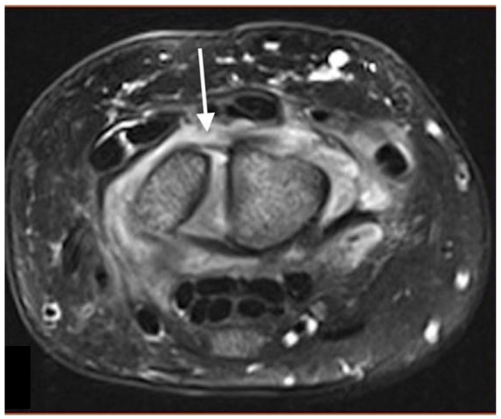

Fig. 7 Our technique: a 63-year-old extremely obese woman with a partial scapholunate ligament tear (*arrow*) on an axial STIR image of the wrist. The image quality was comparable with that obtained using the standard technique

operating at low field strengths (0.2 T), resulting in poor image quality [1, 2, 7]. Open MRI machines are helpful in examinations of distal extremity parts, such as the hand, wrist, elbow, ankle, and knee, which require placement near the center of the magnet in standard MRI to obtain the best images of body parts. The wide open design of upright and open MRI machines allows the positioning of the body part to be examined near the center of the magnet bore. Open sides help to minimize the claustrophobia by allowing the patient to see the surroundings and interact with friends or family members throughout the examination. The noise production is also less than with closed MRI. There are a few limitations of open MRI compared with standard MRI: limited vertical aperture diameter, lower magnet strength, and weaker gradients, which result in a reduced signal-to-noise ratio. However, new open scanner MRI machines with higher magnetic field strengths provide improved image quality. Even high magnetic field strength scanners with a short and wide bore offer improved patient comfort [1, 8, 9].

Few studies have investigated patient's acceptance and the potential to reduce claustrophobic anxiety regarding recent closed MR scanners with noise reduction and short- and wide-bore design in comparison with conventional MR scanners. Dewey et al. conducted a large cohort study by enrolling 55,735 outpatients to assess whether MR scanners with short and wide bore and less acoustic noise are helpful in reducing claustrophobic reaction in comparison with conventional MRI, and authors found a reduction in claustrophobia by a factor of 3 [2]. Another study including 160 patients compared the high-field (1.5–1.0 T) closed MR systems with low-field (0.2 T) open MRI and dedicated extremity MR systems and found more patient preferences for open MRI despite the longer examination time [10]. A pilot study done on recent 1.0 T open MRI including equal number of claustrophobic and non-claustrophobic patients found scan termination rate of 8% on open MRI compared with 58.3% on standard MRI and greater patient acceptance for open MRI without reducing the image

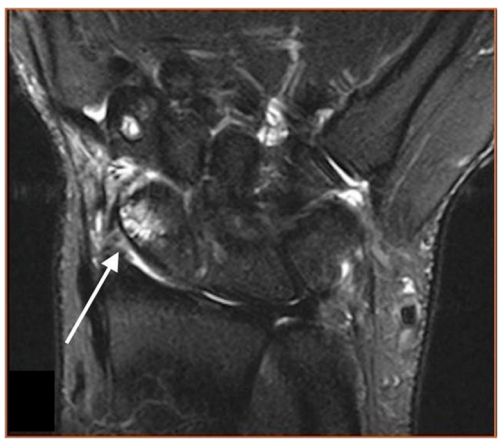

Fig. 6 Our technique: a 50-year-old extremely obese woman with scaphoid bone marrow edema (*arrow*) on a coronal short tau inversion recovery (STIR) image of the wrist. The image quality was comparable with that obtained using the standard technique

Fig. 8 Our technique: a 53-year-old extremely obese man with a scapholunate ligament tear (*arrow*) on a coronal GRE image of the wrist. The image quality was comparable with that obtained using the standard technique

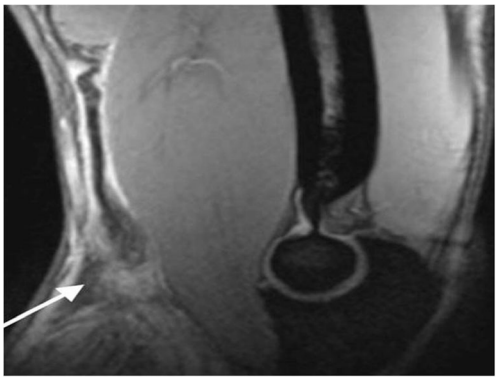

Fig. 9 Our technique: a 64-year-old extremely obese woman with a complete biceps tendon tear (*arrow*) on a sagittal GRE image of the elbow. The image quality was comparable with that obtained using the standard technique

quality [11]. On the other hand, a retrospective study found no significant difference in claustrophobic reactions between the 1.5-T closed MR scanner and the 0.5-T noise-reduced MR scanner [12].

Our technique enables wrist and elbow imaging of extremely obese and claustrophobic patients who cannot otherwise be imaged using a standard MRI scanner without compromising the image quality that is essential for making a diagnosis. It is a more open experience and there is less anxiety for patients who are afraid of closed spaces. However, use of this technique is at a preliminary stage in our institution and we need to compare more cases using our technique with the standard technique. Moreover, this is only useful in certain body parts such as the wrist, elbow, and hands. Without further comparisons, it is not known whether our modified technique offers advantages with regard to clinical and surgical management.

Conclusions

By using this modified technique of non-open standard MRI, claustrophobic and obese patients can sit comfortably for their MRI scan without compromising the image quality and increasing the scanning time. The diagnostic accuracy of this modified technique has not been investigated so far in any well-designed studies and trials that assess clinical and surgical treatment outcomes based on the standard versus the modified technique.

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Compliance with ethical standards

Conflicts of interest Ian Karol MD is a partner at Advanced Radiology Consultants. Other authors declare that they have no conflicts of interest.

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