

The patient positioning in the MR of the shoulder: advantages and disadvantages of the internal, external and neutral rotation of the arm

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ABSTRACT

Tailoring the patient positioning in Magnetic Resonance Imaging, according to patient needs and clinical question, is the key to successfully completing a highly diagnostic exam. This is evident in the MRI study of the shoulder in which, for clinical questions such as subacromial conflict syndrome and suspected lesions of the rotator cuff, is essential to obtain an accurate distension of the tendons, in order to make reporting free from doubtful or improper diagnoses. The possible arm's placements for this kind of examination are: intra-rotation, extra-rotation or neutral position. Each of them presents advantages and disadvantages that the MR radiographer must be able to assess in conjunction with the conditions and the degree of cooperation of the patient. Intra-rotation is clearly the position that ensures greater comfort and stability to the patient and this results in the absence of artifacts from movement, but on the other hand it does not allow the distension of the supraspinatus tendon and the long head of the brachial biceps, it causes the overlap of supraspinatus tendon with infraspinatus one in the oblique coronal sequences, thus leading to misdiagnosis or dubious diagnosis. The arm's neutral position is the ideal one for moderately collaborating patients and promotes a mild relaxation of the tendons and the absence of movement artifacts. Finally, the arm's position in extra-rotation, obtained with variable positioning of pads under the forearm, ensures the collaboration of a substantial number of patients and tendons are well stretched and free from overlap, addressing reliable diagnoses, despite having, as only disadvantage, possible lower degree of cooperation of the patient.

INTRODUCTION

It is now established that a good quality examination in Magnetic Resonance mainly originates from a correct positioning of the patient. That's why the role of the MRI technician is increasingly the key to reach a correct diagnosis. In fact, a wrong positioning of the patient or of the coil or the lack of patient's cooperation potentially negatively affect the success of an MR examination because of the artifacts that can result, frequently leading to misdiagnosis, false positives or false negatives results. The study of rotator cuffs in Magnetic Resonance Imaging is one of the examinations with greater dependence on the patient's positioning, that is the arm's positioning accurately chosen for the resolution of specific clinical questions. The main clinical question for the MRI study of the shoulder is the suspected injury of the tendon of the supraspinatus muscle due to its subacromial course. On the other hand, the MRI of the shoulder shows how the different positioning of the patient's humerus (in intra-rotation, in extra-rotation and in neutral position) strongly affects the final diagnosis potentially leading to false lesions of the supraspinatus tendon. In fact, the superimposition of the supraspinatus and infraspinatus tendons on the oblique coronal

plane given by the humeral intrarotation could lead to the false visualization of not real lesions in both tendons, and, moreover, it is frequently responsible of the visualization of false lesions of the subscapularis tendon or of a decrease of the sensitivity in the diagnosis of glenoid rim's lesions. An adequate knowledge of the insertion and behavior of the tendons of the rotator cuff in relation to the different positioning of the arm and a good evaluation of the degree of collaboration that the patient can offer are the keys to a good success of a MRI study of the shoulder and consequently of a correct clinical diagnosis.

OBJECTIVES

The evaluation of a large number of shoulder MRI studies and the detection of related false positives required the analysis of advantages and disadvantages of the three possible placements of the humerus in the acquisition phase: intra-humeral rotation, neutral position and extra-rotation. The goal was to compare the pros and cons of each placement and to balance the comfort of the patient with the exclusion of artifacts and tendons superimposition, in order to determine which was the best placement among those considered.



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MATERIALS AND METHODS

MRI examinations of the shoulder were performed at the Department of Diagnostic Imaging of the University hospital "Paolo Giaccone" of Palermo, with a MRI scanner 3T Philips Ingenia, (Philips Healthcare, Netherlands Eindhoven) equipped with gradients combined with Amplitude of 45 mT/m and Slew-Rate of 200 T/m/s. The coil used was the dStream Extremity Flex 16ch coil (Fig. 1). The use of a high magnetic field allowed to evaluate the structures of interest with a considerable signal to noise ratio (SNR), making the study as reliable as possible.

The study was conducted in accordance with the standards of good clinical practice and the Helsinki

Declaration. 36 patients between the ages of 32 and 63 years have been prospectively recruited with the following clinical questions: suspected lesion of the tendons of the Rotator Cuff, suspected syndrome of subacromial conflict and suspected lesion of the Long Head of the Biceps. Not all patients were fully cooperative due to their age and related conditions. After receiving the informed consent of the patient, for each patient the same sequence was acquired in three different arm positions (intra-rotation and extra-rotation of the arm and neutral position). The patient was placed supine with pads under the elbow and forearm (Fig. 2-3), very useful especially for maintaining the extra-rotation of the arm, when it is more difficult to ensure comfort and stability to the patient.



Fig 1. dStream Extremity Flex 16ch Coil (Philips Healthcare, Netherlands Eindhoven)

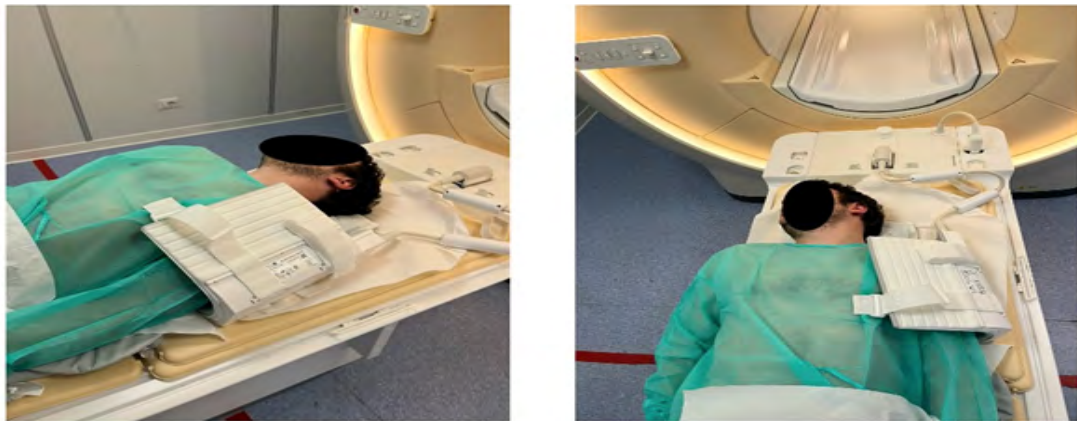


Fig 2. Positioning of the dStream Extremity Flex coil (Philips Healthcare, Netherlands Eindhoven) on the patient in the MRI of the shoulder.



Fig 3. Three different arm's positioning: intra-rotation, neutral position and extra-rotation (from left to right)

A reliable comparison has been obtained between the different behaviors assumed in particular by the supraspinatus tendon and the long head of the brachial biceps. The tendon of the supraspinatus, one of the four muscles belonging to the rotator cuff, is inserted on the upper face of the greater tubercle of the humerus, so that the different degree of humeral rotation favors or not the distension (Fig. 4). The long head of the brachial biceps detaches instead from the supraglenoid tubercle of the scapula to lay inside the bicipital sulcus of the humerus. As the supraspinatus tendon, the extra-rotation of the arm determines its distension. In the cases examined it was chosen to define intra, extra-rotation and neutral position on the axial plane and by measuring angles obtained from the incidence of the glenoid line and a straight line passing through the bicipital groove and the cross-point between the glenoid line and its perpendicular traced in the central point of the glena (Fig. 5). An angle $<45^\circ$ corresponds to the intra-rotation of the arm, an angle of 45° to the neutral position of the arm, an angle $>45^\circ$ to the humeral extra-rotation.

The necessity to obtain the distension of the supraspinatus tendon and the long head of the biceps is particularly important acquiring sequences on the axial plane and on the coronal plane. On the oblique coronal plane, in fact, the superimposition of the supraspinatus tendon and of the infraspinatus

tendon, that is inserted on the medium facet of the great tuberosity of the humeral head, is frequent. The protocol of the shoulder MRI study performed consists in the acquisition of sequences PDw MultiVane XD on the axial plane, PDw SPAIR MultiVane XD on the axial and sagittal plane, T2w MultiVane XD on the sagittal plane, a STIR on the coronal plane and a T1w also acquired on the coronal plane. Of these ones, the Ax PDw and PDw SPAIR MultiVane XD, Cor STIR and Cor T1w have been considered for the study in question, as they show the highest percentages of doubtful and false positives findings.

RESULTS

We found that with angles $<45^\circ$, that corresponds to the intra-rotation position, because the tendon of the supraspinatus muscle is not in distension and the hand with the palmar surface totally leaning on the cot, it ensures the patient maximum stability, absence of pain and comfort, resulting in the total reduction of movement artifacts. On the other hand, not allowing the visualization of the supraspinatus tendon and of the long head of the brachial biceps well extended (Fig. 6), such positioning has caused, in most of the studied cases, also the overlap of the supraspinatus tendon with the infraspinatus tendon in the oblique coronal se-

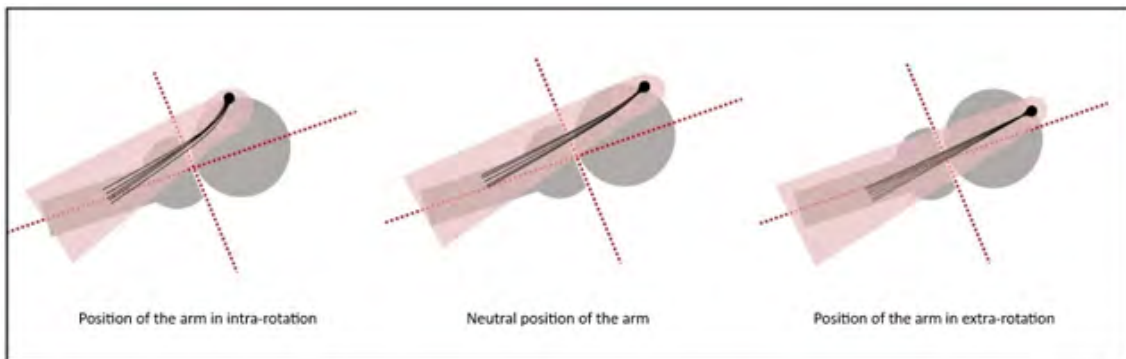


Fig 4. Representation on the axial plane of the tendon of the supraspinatus muscle with insertion at the level of the upper face of the greater tubercle of the humeral head. From left to right: the different positions of the arm determine the distension. The tendon is visible in all its extension in the extra-rotation position and in this case the simulations of pathological conditions are extremely difficult. A tendon discontinuity displayed with extra-rotation will definitely be an injury, while a discontinuity diagnosed with intra-rotation might be considered a doubtful case for the position the tendon assumes due to its anatomical insertion. The arm's neutral position can be considered in the case of patients who are on average collaborator.

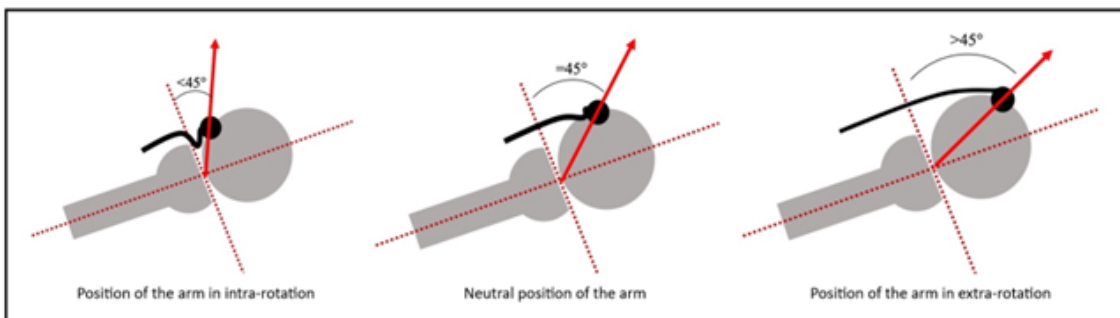


Fig 5. Representation on the axial plane of the long head of the brachial biceps that fits inside the biceps groove. With an angle $<45^\circ$, you get the position of the arm in intra-rotation that, however, keeps the long head of the brachial biceps contracted with potential insinuation inside the glenoid space (first imagine on the left). An angle of 45° corresponds to the neutral position of the arm and is visible a substantial improvement in the degree of relaxation of the long head of the biceps, which reaches its maximum value with angle $>45^\circ$, with extra-rotation of the arm.



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quences (Fig 7). In fact, this position of the humerus causes, in the acquisitions on the coronal plane, the displacement of the connective tissue to articulate inside the virtual space between the infraspinatus and supraspinatus tendons, leading to interpretative doubts about the rupture of the first one.

The neutral position of the arm, on the other hand, allowed patients to stay in the position indicated by the technician until the end of the acquisition without substantial artifacts of movement, but without the total relaxation of tendons. Nevertheless, the test was highly reliable and with a very low percentage of false positive tendon lesions. This placement was great for older patients not suffering from severe algia who were able to cooperate. The position of the arm in extra-rotation was guaranteed by the most collaborative and less sore patients and by some aged ones thanks to the utilization of pads placed under the forearm in a different way tailored from patient to patient. Tailoring the positioning made possible the collaboration of an even greater number of patients than expected, allowing to obtain a high number of MR images in which the tendons were well stretched and free from overlaps. The only disadvantages of this po-

sitioning are therefore the probable low degree of cooperation by the patient determined by the fact that the cuff of the rotators, when well extended, can lead to a greater degree of algia and therefore the presence of artifacts from movement with the risk of premature end of the MR examination (Fig.8-9). Furthermore, sometimes, another disadvantage is the “magic angle” artifact in the tendons of the cuff, but the percentage is really low and the problem is easily solved by slightly changing the position of the patient and lengthening the TE.

The magic angle artifact occurs in structures rich in fiber and collagen, tendon and ligamentous structures, which have a 55° course compared to the main magnetic field. These interactions, however, decrease progressively if the orientation of the fibers is close to 55° compared to the magnet, with an increase in the signal that could simulate a pathological zone.

A solution to this problem is using T1w images, which are affected only minimally by the problem, or increasing the TE above 40 ms which leads to an annulment of the magic angle, but also to the loss of minor inflammatory pathologies.

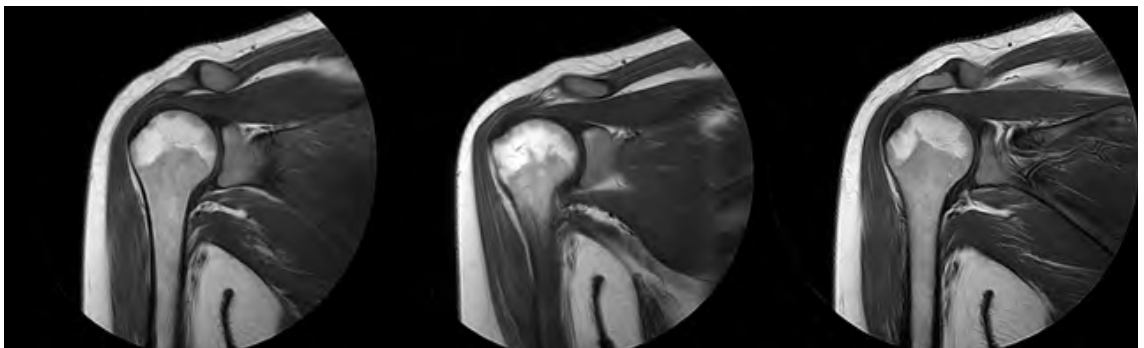


Fig 6. Coronal representation of the MultiVane TSE T1 sequence. From left to right it can be seen that the different position of the arm, respectively in intra-rotation, neutral and extrarotation, involves a different distension of the rotator cuff in particular of the tendon of supraspinatus muscle.



Fig 7. Oblique coronal representation of the shoulder of the MultiVane TSE T1 sequence not adequately stretched due to the position of the intrarotated arm which also involves the overlapping of the supraspinatus tendon with the infraspinatus one.



Fig 8. Ax PDw SPAIR sequence acquisitions in the three arm positions. Left to right: intra-arm rotation, neutral and extra-rotation position. Note how the tendon supraspinatus (insertion indicated with red asterisk) is more and more stretched from left to right in conjunction with the external rotation of the arm.

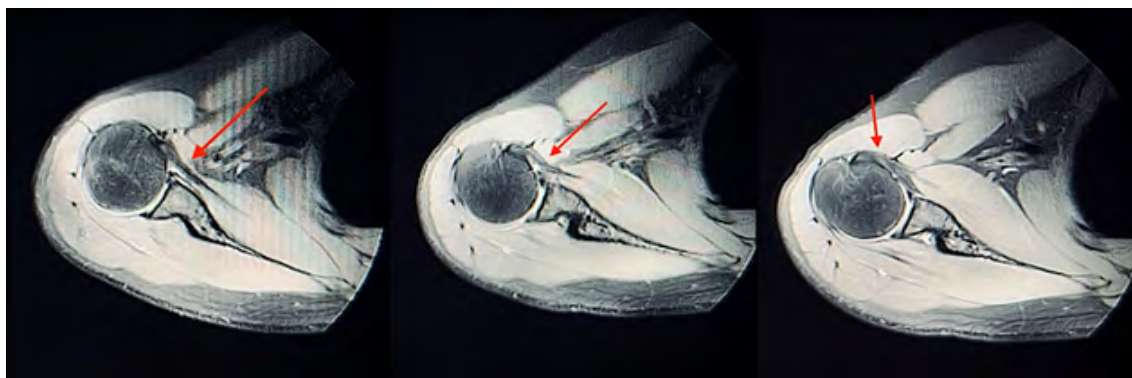


Fig 9. Ax PDw SPAIR MultiVane XD Sequence. The long head of the brachial biceps (red arrow) follows the brachial groove of the humeral head, being not stretched in the first image on the left, with the internal rotation (angle $<45^\circ$), and being gradually stretching in the neutral position (central image, angle of 45°) and in the extra-rotation (last image on the right, angle $>45^\circ$).

DISCUSSIONS AND CONCLUSIONS

Although the continuous and constant technological evolution in Magnetic Resonance Imaging has led to images with high spatial and contrast resolution in the joint, tendon and ligamentous study of the shoulder, the optimization of the images acquired is however strongly related to the skills of the MR technician in the patient positioning. In our study we illustrated that the different positioning and the adequate discrimination of the different degree of collaboration of the patients can lead to a totally different diagnostic level of the same sequence on the same patient. The intra-rotation of the arm was found to be the most comfortable positioning method for the patient, but the one that makes the reporting phase more difficult and insidious. The extra-rotation of the arm with special pads placed under the elbow, forearm and hand of the patient, solves in most cases the problem of their comfort and in addition allows a relaxation

free from overlaps of the tendons of the supraspinatus and the long head of the biceps brachial. Although this position is more suitable for numerous shoulder MRI studies for suspected tendon lesions, it remains the position with the highest percentage of moving artifacts. The neutral position of the arm, finally, is a useful compromise to obtain a medium relaxation of the tendons and at the same time to keep the patient immovable.

The adequate competence of the MRI technician and the use of appropriate equipments is fundamental to obtain MR images of good quality. In addition, we have shown that a good knowledge of the shoulder anatomy is essential for diagnostic purposes. Patients' positioning plays an essential role in discriminating between tendon injuries and false positives findings, but at the same time it is crucial to avoid artifacts due to the positioning of the arm. The role of the Magnetic Resonance Technician must be to make the most suitable choice, understanding which reaches the best compromise in order to optimize the shoulder MR examination.



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