The aim of this study is to determine the efficacy of neutral vs. abduction and external rotation (ABER) position of magnetic resonance (MR) arthrography in evaluation of various shoulder lesions. Eighty-nine patients (90 shoulders) with various shoulder problems were enrolled in this study. Each patient received plain MR imaging with the shoulder in neutral position and fat-suppressed MR arthrography in both neutral and ABER position. The MR images of different positions of each patient were analyzed in a random order.

ABER position MR arthrography (ABER MRA) is better than neutral position MR arthrography (nMRA) in identifying articular side partial-thickness rotator cuff tears (23/90 vs. 17/90), tears of the anterior bands of inferior glenohumeral ligaments (GHL) (11/90 vs. 4/90) and avulsion of anteroinferior labroligamentous complex (24/90 vs. 18/90). In the presence of anterior extravasation of contrast medium (14 shoulders), the ABER greatly facilitates to determine the integrity of the anterior band of inferior GHL, while there was difficulty in interpretation in 8 cases on nMRA.

Regarding to the anterior labral tears, all of them (36 cases) were detected by both ABER MRA and nMRA; nevertheless 10 of the tears at the anteroinferior aspect of the glenoid labrum appear to be more distinct by ABER position than by neutral position.

There was no significant advantage of ABER position over neutral position for the depiction of the morphology and lesions of the long head of biceps tendon, anterior and posterior joint capsule. With regard to the superior glenoid labrum, the superior and middle GHL, ABER position image was worse.

ABER position study is not only supplementary but also mandatory to the routine MR arthrography. We strongly recommend adding the ABER position study as an elementary part of the routine MR arthrography.

Key words: shoulder; glenohumeral joint; magnetic resonance arthrography

Magnetic resonance (MR) arthrography of the glenohumeral joint is generally accepted as the best imaging modalities for detecting intracapsular lesions associated with sports injury or instability, such as SLAP (superior labrum, anterior-posterior) lesion, Bankart lesion, abnormalities of rotator cuff, glenohumeral ligaments, or long head of biceps tendon. Nevertheless, equivocal conditions were still encountered, especially when trying to determine the severity of degree of tears of ligaments or glenoid labrum. In 1994, Tirman et al. first used the abduction and external rotation (ABER) position to facilitate the detection and characterization of tears of the rotator cuff [1]. Subsequent literature also described its usefulness in tears of anteroinferior glenoid labrum [2,3].

In the routine MR study of the shoulder, the humerus is placed in the neutral position. In this position, the major stabilizers of upper part of the glenohumeral joint are under tension and those of the lower part are lax. The situation is reverse when the shoulder is in ABER position. The difference in the
tension is supposed to result in different morphology of the structures and different diagnostic efficacy. In this study we will present our experience of using the two positions for the diagnosis of different internal derangements of the shoulder, including rotator cuff, glenoid labrum and other intraarticular structures.

MATERIALS AND METHODS

Eighty-nine patients with shoulder problem were collected in this study (90 shoulders), including 62 with shoulder instability, 12 with suspected rotator cuff lesion, 3 with suspected SLAP lesions, 6 with pain in ABER position, one with suspected intraarticular osseous bodies, and 5 with vague shoulder pain. There were 79 male and 10 female, aged from 15 to 85 years (average 31.6 years). Plain MR examination of the shoulder was performed with a 1.5-T scanner (Signa; General Electric Medical Systems, Milwaukee, WI) using a shoulder coil (General Electric Medical Systems). The humerus was placed in neutral position. The plain MR study includes T1 weighted (spin echo, TR/TE 420/16) and fat-suppressed proton density (PD) weighted images (fast spin echo, 2000/48 effective) in axial planes, T2 and PD weighted images (fast spine echo, 3000/84 effective and 3000/14 effective, respectively) in oblique coronal planes (parallel to the long axis of the supraspinatus tendon), and fat-suppressed PD weighted images in oblique sagittal planes (parallel to the plane of the gleno-humeral joint).

MR arthrography was performed following the plain MR study. Under fluoroscopic guidance, intraarticular injection of 15 ml of a solution of diluted gadopentetate dimeglumine (Magnevist; Berlex, Wayne, NL) which was made by mixing 1 ml of the contrast medium with 400 ml of normal saline was performed. Fat-suppressed T1-weighted images (spin echo 480/13) were then obtained in three (axial, oblique coronal, and oblique sagittal) planes with the shoulder in neutral position, and in oblique axial planes (parallel to the shaft of the humerus) with the shoulder in ABER position.

The MR images of all patients were separated into three groups (plain MR imaging, neutral position MR arthrography, and ABER position MR arthrography), and were analyzed by an experienced musculoskeletal radiologist who interpreted different groups of images in a random order. The following structures were assessed: rotator cuff, the long head of biceps brachii tendon, glenoid labrum, joint capsule, superior, middle, and inferior glenohumeral ligament (GHL), and miscellaneous structures. In the following text,
neutral position MR arthrography and ABER position MR arthrography will be abbreviated as nMRA and ABER MRA respectively.

**RESULTS**

**Rotator Cuff**

Supraspinatus tendinitis was identified in 30 shoulders by plain MR study, presenting as swelling of the tendon and increased signal intensity on short TE pulse sequence. Of these, only 4 were depicted on MR arthrography with fat-suppressed pulse sequence. Articular side partial-thickness rotator cuff tears were found in 23 shoulders by ABER MRA. Four of these lesions were undetected by both plain MR and nMRA. Although nMRA detected more lesions than plain MR did (17 vs. 11), there were still 2 detected on plain MR but missed or uncertain on nMRA. (fig. 1a, b and c)

Full-thickness tears were found in 4 shoulders which were detected by all three modalities without disagreement.

Bursal side partial-thickness tear was suspected in one shoulder by plain MR which cannot be visualized by both nMRA and ABER MRA.

**Long head of biceps tendon (LHBT)**

There was one degenerative thinning of LHBT detected in this series which was identified by all three modalities. Two partial tears of LHBT were detected by neutral and ABER position MR arthrography while missed on plain MR. Kinking or wavy appearance of the intracapsular portion of the tendon was noted in ABER position. Generally speaking, the LHBT is better visualized in neutral position than in ABER position.

**Superior and middle glenohumeral ligaments (GHLs)**

The superior GHL was identified in 89 shoulders by nMRA. These structures were distorted and difficult to be evaluated on ABER MR images. Tear of the ligament was found in 2 patients which were visible on nMRA only.

The middle GHL was best depicted in nMRA. Seven tears and 4 congenital aplasia were found. None of these lesions can be determined on plain MR imaging and only one tear was confidently diagnosed by ABER MRA.

**Inferior glenohumeral ligaments and anteroinferior labroligamentous complex**

Tears of the anterior band of inferior GHL were identified in eleven shoulders by ABER position. Of them, two were negative and 5 were indeterminate on the neutral position images (fig 2a and b). Avulsion of the anteroinferior labroligamentous complex was evi-

![Figure 2](image_url)

**Figure 2.** Rupture of the anterior band of the inferior glenohumeral ligament in a 27-year-old male. a. Neutral position MR arthrography at lower level of the joint revealed a small tear (arrow) in the anterior band of the inferior glenohumeral ligament. The letters A and P indicate the anterior and posterior aspect of the glenohumeral joint respectively. b. The tear was much more evident and obvious in ABER position (arrows). Also note the Bankart lesion with chronic avulsion of the anteroinferior labroligamentous complex (arrowheads). The letters AI and PS indicate the anteroinferior and posterosuperior aspect of the glenohumeral joint respectively.
dent in 24 shoulders by ABER position (fig 3a and b). Neutral MR arthrography failed to detect 6 of these avulsion and the plain MRI only pick up 5 lesions.

Anterior extravasation of contrast medium was present in 14 shoulders, resulted either from anterior capsular tear or from technical factor. On nMRA the leaked contrast medium can cause difficulty in the interpretation of the integrity of anterior band of inferior GHL. Of these exams with extravasation, 4 inferior GHLs were considered to be torn and 4 were indeterminate, and turn out to be only two tears on ABER MRA while all the others were negative (fig 4a and b).

Glenoid labrum

Thirty-six anterior labral tears were revealed by axial view of nMRA and by ABER MRA. Although they were detected by both modalities, 10 of the tears at the anteroinferior aspect of the glenoid labrum appear to be more distinct by ABER position than by neutral position.

Eight SLAP lesions were diagnosed by oblique coronal views of MR arthrography in neutral position. Four of them were suspected on plain MR imaging and none were diagnosed by ABER images (fig 5a, b and c).

Anterior and posterior joint capsule

Stripping of the anterior or posterior joint capsule was identified in 50 shoulders, both by MR arthrography obtained with neutral and ABER positions. This information was not obtained by the plain MR imaging except in one patient who have moderate amount of effusion in the glenohumeral joint.

Miscellaneous

Plain MR imaging revealed 16 shoulders with subacromian-subdeltoid bursitis, 3 with acromioclavicular joint effusion, one with moderate amount of glenohumeral effusion, one with labral cyst, one with suprascapular ganglion cyst, and one with intramuscular (supraspinatus) ganglion cyst. None of these lesions were detected during the interpretation of MR arthrography. The three cysts were retrospectively
DISCUSSION

MR arthrography was less sensitive for tendinitis of rotator cuff than plain MR imaging in our series (30/90 vs. 4/90). This was probably related to the fat suppression technique we used. The MR criteria for tendinitis included swelling of the tendon as well as increased signal intensity on short-TE pulse sequence but preserved on T2-weighted images. On MR arthrography, fat suppression was used in order to increase the sensitivity for detecting abnormal leakage of contrast medium. However, in this way it also render the bursal margin of rotator cuff less distinct since the peribursal fat plane was absent, so the thickness of the tendon was somewhat difficult to be evaluated. The dynamic range used in fat-suppressed image was wider than a usual T1-weighted image, thus making the change in the signal intensity of the tendon less well perceived. Probably due to the combined effect of the above two factors, the detection rate of rotator cuff tendinitis was extremely low as compared with that of plain MRI.

It has been stated in the literature that MR arthrography is much better than plain MR in detection of articular side partial-thickness tear of the rotator cuff. ABER position further increases the sensitivity for articular side partial-thickness tear [1,4]. Our study also supported the above statement (ABER/neutral: 23/17). It is most likely due to the lax status of the supraspinatus and infraspinatus tendons which facilitate the seepage of contrast medium through the tear and dissection into the tendon substance.

The GHLs are thickenings of the anterior joint capsule that extend from the anterior aspect of the glenoid rim to the proximal portion of the humerus. The superior GHL is a fairly constant structure [5]. It arises in the glenoid labrum just anterior to the insertion of the long head of the biceps tendon and inserts just superior to the lesser tuberosity in the region of bicipital groove. The superior GHL is readily identified on neutral position MR arthograms, appears as fold-like or cord-like structure along the superior portion of joint capsule, and is best depicted in the axial and oblique sagittal planes [6,7]. It is difficult to identify the superior GHL on plain MR image when there was no obvious joint effusion. It is also not easily demonstrated on ABER position, probably because of the laxity and distortion of the superior joint capsule.

The middle GHL showed great variation in configuration and size [5,6]. Superiorly, it generally appeared as a discrete intraarticular band that was

Figure 5. Type 3 SLAP lesion in a 42-year-old patient with history of habitual dislocation. A bucket-handle type tear of the superior glenoid labrum was suspected on plain MRI (a), evident on MR arthrography in neutral position (b), but was not diagnosed by the ABER MR arthrography on which the tear mimicked normal sublabral recess (c), Arrows: superior glenoid labrum. Arrowheads: the tear.
freely separable from the anterior joint capsule. It then became part of the capsule as it descended to the humeral attachment. The free intraarticular part occasionally was very short or even absent, leaving the MGHL only as a focal thickening or folding of the anterior joint capsule [6,7]. In the neutral position, this ligament is best depicted on oblique sagittal MR arthrographic images, while the axial images show the transectional dimension of the MGHL clearly. The ABER position does not facilitate the identification of middle GHL in our series.

The inferior GHL is the largest and most important of the GHLs. It consists of an anterior band, a posterior band, and an axillary recess of the capsule between these bands. The anterior and posterior bands are attached to and contribute to the formation of the anterior and posterior portions of the labrum. The ligament inserts in a collarlike fashion into the inferior aspect of the humeral neck [6]. It is lax in adduction and becomes tighter with increasing abduction of the humerus.

Just like some of the prior literatures, our study also revealed that MR arthrography with the patient's shoulder in the ABER position is more efficient than conventional axial scanning in revealing the degree of tear or defect of the anteroinferior glenoid labrum [2,3] and anterior band of inferior GHL. The ABER position leads to tension in the inferior GHL and anteroinferior portion of the labrum, allowing distraction and therefore more visualization of labral tear when compared with the images obtained in neutral position.

The helpfulness of the ABER MRA over the neutral position MRA in the presence of anterior extravasation of contrast medium had never been mentioned by prior literature. Anterior extravasation of contrast medium can occur as a result of anterior capsular tear or technical factor. On neutral MRA, the leaked contrast medium can cause difficulty in the interpretation of the integrity of anterior band of inferior GHL. This can be improved by the ABER position. The anterior band of the inferior GHL became tightened and straight in ABER position, thus its integrity can be easily determined in spite of the presence of extravasated contrast medium in the adjacent area. In our experience, the ABER position was very helpful in judging the intactness or tear of the anterior band of inferior GHL with the presence of extravasation of contrast medium.

The influence of different shoulder positions with regard to visualization of the posterior and the anterosuperior portions of the glenoid labrum was minimal, based on the observation in our series.

The imaging plane used for ABER MR arthrography was also not optimal for superior glenoid labral lesion. The axis of glenoid process corresponds to the oblique trans-axial plane [1,2] and therefore bear a similar appearance to the axial view of the shoulder in neutral position. In our series, eight SLAP lesions were diagnosed by oblique coronal views of MR arthrography in neutral position. However, in ABER MR arthrography, they appeared as contrast medium seepage between the superior glenoid labrum and the glenoid hyaline cartilage, and were indistinguishable from the sublabral recess, which was a normal variation.

The potential difficulties in interpreting images obtained with the shoulder in ABER position mainly arise from unfamiliarity with the anatomic change. Visualization of the superior and middle GHLs was also difficult in this position. Therefore, the ABER position should not be used to replace any of the routine planes of MR arthrography obtained with the shoulder in neutral position. Nevertheless, the ABER position MR arthographic images improved the diagnostic sensitivity of MR arthrography in partial-thickness rotator cuff tear, inferior GHL and anteroinferior glenoid labral tear as compared with those obtained with the shoulder in neutral position.

Our study revealed that there was no significant advantage of ABER position over neutral position for the depiction of the morphology and lesions of the long head of biceps tendon, anterior and posterior joint capsule. With regard to the superior glenoid labrum and the superior and middle GHL, visualization of these structures or determination of lesions was also deterred in ABER position and interpretation was more difficult than in neutral position MRA.

The major limitation of our study was the lack of surgical or arthroscopic correlation, which was not available in most of our patients since they came to our institute just for certification of their diseases used for military service. Therefore there was no unique gold standard in our study, and it was difficult to determine the false positive and negative diagnostic rate for the various portions of joint structures by nMRA or ABER MRA.

ABER position study is not only supplementary but also mandatory to the routine MR arthrography. However, the ABER position should not replace any of the routine planes of MR arthrography obtained with the shoulder in neutral position. ABER MRA enhances the detection rate of partial-thickness rotator cuff tear and lesions of anteroinferior portion of glenoid labrum and anterior band of inferior GHL. In the presence of extravasation of contrast medium, the
ABER greatly facilitates the determination of the integrity or tear of the anterior band of inferior GHL. We strongly recommend adding the ABER position study as an elementary part of the routine MR arthrography.

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REFERENCE

磁振關節攝影術對於肩關節之評估：正位與ABER位的比較

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本文的目的是分析與統計正常位與上舉外轉（abduction and external rotation，ABER）位對於關節內各種結構與病變在影像特徵上之影響與意義。我們收集了89個具明確或不明顯受傷病史之肩部疼痛病例（90個肩關節），先將上臂置於正常位，施以一般肩關節磁振造影檢查。然後施以磁振造影關節攝影術，將gadolinium-DTPA 稀釋溶液注射入盂肱關節，再將上臂置於正常位與ABER位，分別進行磁振造影術。

肩旋轉肌之肌腱炎的診斷以一般肩關節磁振造影檢查最容易（30例），其中只有4例能在磁振造影關節攝影術診斷出來。旋轉肌腱部分斷裂的偵測能力以ABER位之磁振造影關節攝影術最佳（23例），其次為正常位的磁振造影關節攝影術（17例）。完全断裂者有4例，在三種檢查均可正確診斷。

前下孟肱韌帶斷裂者有11，均由ABER位之磁振造影關節攝影術診斷，其中2例在正常位的磁振造影關節攝影術判為陰性，5例則不易判斷。

前側孟脣軟骨之裂傷有36例，其於正常位與ABER位之磁振造影關節攝影術之診斷率相同，但ABER位對於前下側孟脣軟骨之裂傷有加強的效果（10例），對於病灶的顯示較正常位為清楚。

在二頭肌，前後關節囊方面，ABER位之磁振造影關節攝影術並不如正常位好，對於上盂肱韌帶，中盂肱韌帶，上側孟脣軟骨等，ABER位之磁振造影關節攝影術甚至比正常位好。

我們的研究顯示，ABER位之磁振造影關節攝影術沒有取代正常位磁振造影關節攝影術的角色，但其對於旋轉肌腱部分斷裂，前下孟肱韌帶斷裂，及前下側孟脣軟骨之裂傷卻有極重要的輔助效果，我們認為應將其加入常規的磁振造影關節攝影術中。

關鍵詞：肩關節，磁振造影，關節攝影術