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Original article

Clinical application of radial magnetic resonance imaging for evaluation of rotator cuff tear

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ABSTRACT

Background: Magnetic resonance imaging is useful for evaluating the rotator cuff, but some tendinous insertions cannot be assessed using oblique sagittal, oblique coronal, and axial magnetic resonance (MR) images because of the presence of the partial volume effect.
Hypothesis: The purpose of this study was to determine whether radial-slice MR images could reveal normal rotator cuff insertions and rotator cuff tears more clearly than conventional MR images.
Patients and methods: The study included 18 subjects with normal rotator cuffs and 30 with rotator cuff tears. MR images of rotator cuff insertions sliced into radial, oblique coronal, and axial sections were obtained. The extent to which normal rotator cuff insertions and rotator cuff tears were visualized in each of the three MR images was evaluated.
Results: The top to posterior portions of the rotator cuff insertions from 0° to 120° could be visualized in the radial MR images. In comparison, the posterior portions of the rotator cuff insertions could not be visualized around 45° in both the oblique coronal and axial MR images.
Discussion: These findings demonstrate that radial MR images are superior to the oblique coronal and axial MR images regarding their ability to accurately visualize rotator cuff insertions. Radial MR images also revealed greater detail around 45° in the posterior area of the rotator cuff tears than the oblique coronal and axial MR images. Radial MR images are particularly useful for visualizing clinically important posterosuperior rotator cuff tears.
Level of evidence: Level III – Diagnostic study.

1. Introduction

The rotator cuff (RC) comprises four tendons of the subscapularis, supraspinatus, infraspinatus, and teres minor muscles, which surround the humeral head [1]. These tendons attach to the greater and lesser tuberosities of the humerus. Most RC tears occur at these tendinous insertions to the humeral head, and although the sizes of tears may vary, surgical repair is typically performed when symptoms including pain and restriction of shoulder motion persist [2,3]. Successful RC repair requires a proper understanding of the size of the tear and the condition of the torn tendon preoperatively. Various studies have described the utility of magnetic resonance imaging (MRI) for detecting RC injuries. The sensitivity and specificity of MRI in the diagnosis of RC tears have been shown to be very high, at 90% [4–8].

Oblique sagittal MRI provides the location and size of the tear in the anteroposterior direction, perpendicular to the RC tendons. In addition, MRI parallel to the RC tendons is commonly used for the detection of retracted torn tendons; oblique coronal MRI, for the superior part of the supraspinatus tendon; and axial MRI, for the major part of subscapularis and infraspinatus tendons. These MRI settings also allow for the evaluation of the articular and bursal side tears on the bone-tendon insertion [9]. However, no plane of the oblique coronal or axial MRI provides a proper cross-section of the tendons in their anterosuperior and posterosuperior regions because of the circumferential attachment of the RC tendons to the humeral head, resulting in poor visualization of the tendons due to the artifact of partial volume effect [10]. To avoid this artifact, radial MRI is reported to be useful for the visualization of

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the circumferentially attached acetabular labrum of the hip joint [11–13]. Therefore, we hypothesized that a radial MRI centered on the humeral head provides a wider range of visualization of the RC insertions than the conventional combination of oblique coronal and axial MRI (conventional setting MRI).

To confirm this hypothesis, we compared the observable regions in radial and conventional setting MRI in regard to the following: the insertion of the RC tendon in cases without tear and the torn tendon edge of the cases with cuff tear, including the supraspinatus portion. In addition, the detectability of the intratendinous delamination of the torn edge, which required additional arthroscopic suturing besides the usual tendon-to-bone repair, was compared between each MRI setting.

2. Patients and methods

2.1. Patients

Eighteen patients (18 shoulders), comprising 13 men and 5 women (age, 15–38 years; mean, 21.5 years) with a diagnosis of glenoid labrum injury and without tear of the RC, who underwent shoulder arthroscopy between January 2011 and March 2013 were assessed in this study. Cases in which the RC tears were found during the shoulder arthroscopy were excluded.

Thirty patients (30 shoulders), comprising 15 men and 15 women (age, 53–69 years; mean, 63.3 years) with a diagnosis of the RC tear including the supraspinatus portion, who underwent shoulder arthroscopy between January 2011 and March 2013 were assessed in this study.

2.2. Ethical review committee statement

Ethical approval was obtained from the ethics committee of Kyoto Prefectural University of Medicine (ERB-C-163).

2.3. MRI protocol

The MRI system used was a 3.0 T (Achieva 3.0 T X-series; Philips Healthcare, Best, the Netherlands), with a dedicated 4-channel shoulder coil. Subjects were placed in the supine position with their arms on the sides. The elbows were fully extended with the palm upward.

Oblique sagittal, oblique coronal, and axial MRIs were set according to the conventional method: oblique sagittal, perpendicular to the scapula axis; oblique coronal, parallel to the scapula axis; and axial, perpendicular to the body axis. Fat-suppressed T2-weighted images with a 3.0-mm slice thickness and 0.3-mm slice gap [14,15] were used. Oblique coronal and axial MRIs were comprehensively defined as the conventional setting MRIs in this study.

Radial MRI was planned on the oblique sagittal image. The center of radial planes was set at the mid-point of the humeral head on the image in which the lesser tuberosity was best depicted. Twenty-four fat-suppressed T2-weighted images with a slice thickness of 3.0 mm were obtained at 7.5° intervals (Fig. 1).

The image acquisition time was approximately 3.5 min for the oblique sagittal, oblique coronal, and axial MRIs, respectively, and 4 min for radial MRI. The difference of imaging time is reflected by slice numbers. Oblique sagittal MRI was used as reference for the position confirmation on each section of the oblique coronal, axial, and radial MRIs.

2.4. Evaluation of MRIs

The evaluations were focused on the posterior half of the shoulder joint. The evaluated position was recorded as the angle from the uppermost position at 7.5° intervals, such as SP30 (30° from superior to posterior). The uppermost region was expressed as SP0. The position on the oblique coronal and axial images was rounded to the nearest angle at 7.5° intervals (Fig. 2).

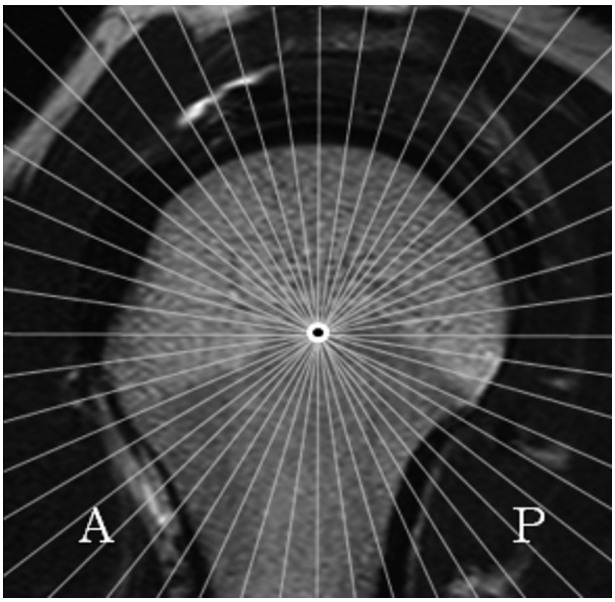

Fig. 1. Radial image setting. Slice selection was based on a reference image positioning the sagittal plane parallel to the glenoid fossa of the scapula, with a total of 24 slices acquired at 7.5° intervals around a rotation axis formed by the line connecting the mid-points of the glenoid fossa and humeral head.

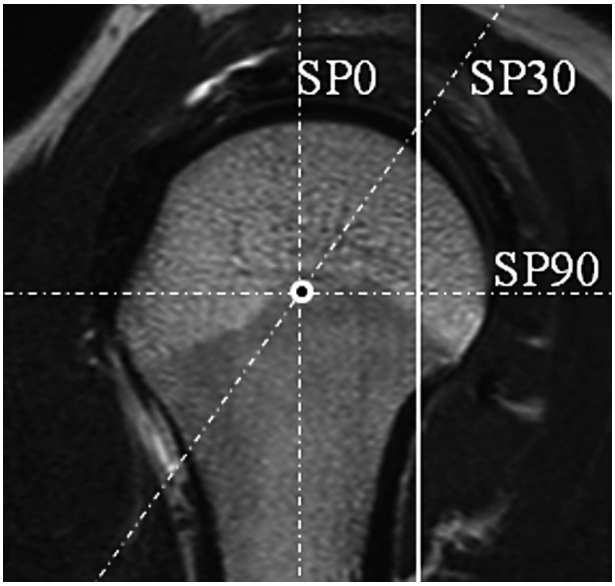

Fig. 2. Notation of the tendon region in radial and conventional images. The region at the top was defined as SP0; and 30° towards the posterior region form the top was recorded as SP30. The region of evaluation in the oblique coronal and axial planes was recorded similar to the 7.5° interval. The region of evaluation of the oblique coronal image in this case was recorded as SP30.

For the evaluation of the cuff insertion in the cases without RC tear, detectability of tendon continuity to its bony insertion was evaluated on each section of the radial MRI and conventional setting MRIs.

In the cases with RC tear, the findings of the RC at the tear were judged as “continuous”, “torn”, or “undeterminable” on each slice. The judgment “continuous” meant that the continuity of the RC to its bony insertion was completely observable. The ranges where