Radial Reformation of 3D Fat-suppressed Multi-echo Gradient-recalled-echo Images in the Evaluation of Acetabular Labral Injuries and Femoroacetabular Impingement

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Aims and objectives

The evaluation of acetabular labral injuries and femoroacetabular impingement (FAI) is difficult using standard 2D MRI sequences. Although radial 2D MRI is useful for evaluating acetabular labral injury [1], slice acquisition is limited within reasonable scan times. Advantages of 3D isotropic acquisitions of MRI include a high signal-to-noise ratio (SNR), high spatial resolution, and the ability to yield high-quality multiplanar reconstruction (MPR) images [2, 3]. The aim of this study was to evaluate the utility of two radial reformations of 3D fat-suppressed multi-echo gradient-recalled-echo (FS multi-echo GRE) images in the evaluation of acetabular labral injuries and FAI. First, we evaluated the diagnostic accuracy of radial reformation through the center of the acetabulum perpendicular to the plane across the entire acetabular rim (type-1 radial reformation) for evaluating acetabular labral injury by comparison with radial 2D T2*WI. Second, we confirmed the utility of radial reformation perpendicular to the central axis of the femoral head and neck (type-2 radial reformation) for evaluating FAI morphology in patients suspected with acetabular labral injury.
Methods and materials

Patients

Our study was approved by our institutional review board. Informed consent was obtained from each patient. We recruited 25 patients (11 men, 14 women; mean age, 45±16 years) with suspected acetabular labral injury.

MR imaging

All images were obtained on a 3T MR unit (Philips INGENIA 3.0T; gradient strength = 40 mT/m, slew rate = 150 T/m/s) using ds Anterior and ds Posterior coil. We optimized the 3D FS multi-echo GRE sequence (TR 32 ms, TE 2.3/5.6/8.9/12.2/15.5 ms (5 echoes), flip angle 7°, FOV 350x280 mm (RFOV 80%), matrix 352x282, pixel size 1x1x1 (ZIP 0.5x0.5x0.5) mm, number of acquisitions 1, BW 538 Hz/pixel, SPIR (CHESS) +, scan time 5 m 30 s) and radial 2D T2*WI sequence (TR 400 ms, TE 18.4 ms, flip angle 30°, FOV 160x160 mm, matrix 320x320, slice thickness 4 mm, pixel size 0.5x0.5 mm, number of acquisitions 2, BW 517 Hz/pixel, slice numbers 12, scan time 5 m 25 s). Radial T2*WI through the center of the acetabulum perpendicular to the plane across the entire acetabular rim of the right hip joints of 15 patients and the left hip joints of 10 patients and axial 3D FS multi-echo GRE imaging of their both hips were acquired.

Radial reformation methods of FS multi-echo GRE for evaluating acetabular labral injuries and FAI

We performed type-1 radial reformation through the center of the acetabulum perpendicular to the plane across the entire acetabular rim at 15° slice intervals for evaluating acetabular labral injury (Fig. 1a) and type-2 radial reformation perpendicular to the central axis of the femoral head and neck at 15° slice intervals for evaluating FAI (Fig. 1b).

The diagnostic accuracy of acetabular labral injury using type-1 radial reformation

The range of acetabular labral injury of each patient was evaluated by the consensus decision of two experienced radiologists. Two weeks after interpreting radial 2D T2*WI, the same radiologists evaluated labral injury on type-1 radial reformation of 3D FS multi-echo GRE imaging. Diagnostic accuracy using the type-1 radial reformation was assessed in comparison with radial 2D T2*WI. The locations of acetabular labral injury were classified as eight zones (anterior, anterosuperior, superior, posterosuperior, posterior, inferoposterior, and inferior zones).
The evaluation of FAI using type-2 radial reformation

The degree of FAI morphology was estimated using type-2 radial reformation of 3D FS multi-echo GRE imaging. FAI was diagnosed based on previously published methods (Fig. 2a,b). An # angle over 55° was considered indicative of cam-type FAI [4, 5]. Pincer-type FAI was diagnosed based on over-coverage of the acetabulum. Acetabular depth < 0 was defined as pincer-type FAI [6].
Fig. 1: Fig. 1 (a) Twelve radial slices through the center of the acetabulum perpendicular to the plane across the entire acetabular rim at 15° slice intervals are obtained from type-1 radial reformation. (b) Twelve radial slices perpendicular to the axis from the center of the femoral head through the central axis of femoral neck at 15° slice intervals are obtained from type-2 radial reformation.

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**The evaluation of FAI**

(a) The $\alpha$ angle is formed by two lines. The first line is drawn from the center of the femoral head through the central axis of the femoral neck. The second line is drawn from the center of the femoral head to the point where the femoral head/neck junction diverges from a best fit circle drawn around the perimeter of femoral head. The $\alpha$ angle $> 55^\circ$ was defined as cam-type FAI. (b) The AC depth is defined as the distance between the line connecting anterior and posterior edge of the acetabulum and the center of femoral head. The AC depth $< 0$ mm was defined as pincer-type FAI.

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Results

The results in details of our study was shown in Table. We identified labral injuries in 23 patients and no labral injury in 2 patients from type-1 radial reformation and radial 2D T2*WI. We found 50 zones with labral injury in all patients (anterosuperior zone, n=17; anterior zone, n=13; posterosuperior zone, n=8; superior zone, n=7; posterior zone, n=3; posteroinferior zone, n=2). The rate of diagnostic concordance concerning the range of labral injury was 80.0%. FAI could be evaluated in all patients (no FAI, n=9; cam, n=9; pincer, n=4; combined cam and pincer, n=3) using type-2 radial reformation. Representative cases are shown in Figure 3 and 4.
Table 1: The results of our study are shown in Table.

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Fig. 3: Fig. 3 A representative case with acetabular labral injury is shown. Radial 2D T2*WI and type-1 radial reformation of 3D FS multi-echo GRE demonstrate labral injury at 3 angles and subchondral cysts.

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Fig. 4: A representative case with acetabular labral injury and combined type FAI is shown. Type-1 radial reformation of 3D FS multi-echo GRE demonstrates labral injury and herniation pit. On type-2 radial reformation, # angle and AC depth are 57° and -3 mm, respectively, and which is considered indicative of combined type FAI.
Conclusion

Type-1 radial reformation of 3D FS multi-echo GRE imaging is useful for evaluating the range of acetabular labral injury and provides complementary information to radial 2D T2*WI. Type-2 radial reformation enables us to determine whether patients with labral injury have FAI, respectively.

Limitations

Potential disadvantages of 3D isotropic GRE imaging include relatively long acquisition times and inherent sensitivity to susceptibility artifacts, which may be problematic in emergency and postoperative patients. The most weakness of this study was the lack comparison with findings from MRI and arthroscopy.
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References


