Hip MR Arthrography for Acetabular Labral Tears

Tears of the acetabular labrum are an uncommon cause of hip pain. A snapping sound may also accompany labral tears, although this sign is by no means specific for that disorder and may be found with a variety of abnormalities most commonly the snapping of the iliotibial band over the greater trochanter.

IMAGING OF ACETABULAR TEARS

BASIC PROTOCOL

It is the authors' opinion that the MR assessment of labral tears should be performed as an MR arthrogram, employing an array or surface coil and using higher resolution than that employed for routine MR examinations of the hip MR. The authors also believe that these studies should not be attempted on systems with static field strength <1 Tesla, because of the considerable demands placed on these systems to evaluate the labrum, in particular, the need for high resolution and fat saturation. (Not all investigators agree with the necessity of using arthrography, however. At least one investigator maintains that intra-articular contrast is not needed if sufficiently high resolution is employed. A different group of investigators performed MR arthrograms on a group of patients using a 0.5-T system for some patients and a 1.0-T system for others. These investigators did not describe any difference in accuracy between the two systems, although, they did not directly address this issue.) Under fluoroscopic guidance, a small amount of iodinated contrast agent is injected to confirm intra-articular location of the needle. A small amount of dilute Gd-chelate in saline, bupivicaine, and betamethasone is injected into the joint. Bupivicaine, a long-acting anesthetic, is used to confirm the intra-articular origin of the pain, as well as to provide short-term relief of symptoms. Betamethasone, a long-acting steroid, is used to provide somewhat longer-term symptomatic relief. Following the acquisition of a scout sequence in the coronal plane, fat-saturated, T_1-weighted, fast-spin echo sequences in the transverse, coronal, and sagittal planes are obtained. Fast spin echo (FSE) sequences are used because fat saturation, when used with short T_E FSE sequences, increases the study time much less than when used with short T_E conventional spin echo sequences (CSE). The authors also set the second echo of the echo train in the FSE sequence to two times the minimum T_E as the effective T_E because of reduced blurring compared with use of the first echo. See Kowalchuk et al. (2000) for further discussion of the rationale for using the second echo of a fast-spin echo sequence as well as demonstrating its accuracy for the assessment of knee meniscal tears. To keep this effective T_E <30 msec while using the second echo of the train requires relatively strong gradients and wide bandwidth. This type of sequence cannot be performed on all systems. In particular, if the gradients are not sufficiently strong, fat-saturated, T_1-weighted CSE sequences are used and more time is taken to perform the study. Other investigators have advocated the use of 3-D, T_1-weighted, short T_R, gradient sequences. The authors have had no experience with these sequences for this application.

The authors typically use a small FOV (200 to 240 mm) and a 256 by 192 acquisition matrix. These are followed by a long T_E FSE sequence with fat saturation, obtained in either the coronal or the transverse plane. This last sequence is primarily used to look for disease in the marrow or surrounding soft tissues. When performed with FSE sequences, this imaging protocol should require <30 min from start to finish.

Table A26.2.1 lists the hardware necessary to perform the procedure, along with appropriate parameters. The available gradient strength will depend on the scanner and determines whether to use an FSE sequence or a CSE sequence as described above.

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Current Protocols in Magnetic Resonance Imaging (2003) A26.2.1-A26.2.11

Table A26.2.1 Equipment Parameters for MR Arthrography of the Hips for Acetabular Labral Tears

Coil type	Torso array coil (or similar local coil)
Gradient coil strength	25 mT/m (or whatever the system permits)
Cardiac gating	No
Peripheral gating	For safety only
Respiratory gating	No
Respirator	If required by patient
Oxygen	If required by patient
Motion cushions	Useful
Use of contrast agents	Yes (intra-articular injection performed with fluoroscopic guidance prior to MR)

NOTE: Be sure that technologists and nurses have immediate access to any emergency equipment that may be relevant to a given study, or that may be needed for a particular patient, such as crash carts or oxygen.

Materials

Betamethasone
Bupivicaine MPF (methyl paraben–free)
Gd-chelate
Iodinated contrast agent
Saline

Set up patient and equipment

1. Interview (screen) the patient to ensure that he or she has no contraindications such as cardiac pacemakers or other implants containing ferromagnetic materials. Also be sure to find out if the patient has any health conditions that may require the presence of special emergency equipment during the scanning procedure, or necessitate any other precautions. The patient should be questioned as to the location of the pain, in the particular side.

   Generally, standard screening forms (APPENDIX 1) are used for all patients scanned in a magnetic resonance system.

   The presence of any ferromagnetic metals may be a health hazard to the patient when he or she is inside the magnet, and will also affect the imaging. If in doubt as to the exact composition of the items, it is best to exclude patients with any metal implants; see Shellock (1996) for a discussion of what implants may be safely scanned using magnetic resonance.

   Patients may be accompanied into the magnet room by a friend or family member, who can sit in the room during the scan and comfort the patient as needed. This companion must be treated as if he/she was having the MR examination him- or herself to ensure the absence of loose metal objects on the body or clothing. Because of the need for a sterile field, the authors recommend that the companion not be permitted in the fluoroscopic suite. If the companion must be in the fluoroscopic suite to perform the procedure, appropriate radiation protection (i.e., a lead apron) must be worn and the observer is kept at a reasonable distance from the sterile field.

2. If the procedure is a research protocol, have the patient sign any necessary consent forms.

3. Have the patient remove all jewelry and change into a gown to eliminate any metal that might be found in clothing.

4. Perform a hip arthrogram under fluoroscopic guidance. Inject a small amount of iodinated contrast agent into the hip joint using standard technique to establish the intra-articular location of the needle. Inject into the hip a solution consisting of 0.2 ml Gd-chelate, 5 ml saline, 1 ml (6 mg) betamethasone, and 5 ml bupivicaine MPF. Pre-mix this solution in a small saline bottle by withdrawing 15 ml from a 20-ml vial and adding the other compounds in order to reduce time in the fluoroscopic suite. Inject the entire 11.2 ml of the solution into the hip followed by an injection of up to 10 ml of saline. This last saline injection may be halted before the full 10 ml is administered if either the patient experiences pain or considerable backpressure is felt.

   The patient's assessment of the change in hip pain following the injection of the betamathasone and bupivicaine is used by the referring physician to confirm that intra-articular structures especially the labrum are the cause of pain, as well as to deliver short-term relief from symptoms.

   The MPF formulation is used to prevent precipitation with the betamethasone.

5. Take the patient by wheelchair to the MR system.

6. Inform the patient about what will occur during the procedure, what he or she will experience while in the magnet, and how to behave, including the following:

   a. If earphones or headphones are used to protect the ears from the loud sounds produced by the gradients, the patient will be asked to wear these, but will be able to communicate with you at any time during the imaging.

   b. The patient will be given a safety squeeze-bulb or similar equipment to request assistance at any time (demonstrate how this works).

   c. For good results, the patient should not talk, and should avoid or minimize other movement during each scan—i.e., as long as the banging sounds continue. Between scans, talking is allowed in most cases, but should be avoided when comparative positional studies are being performed; the patient will be informed when this is the case.

   d. Nevertheless, the patient may call out at any time if he or she feels it necessary.

7. Have the patient lie down on the table with his or her feet toward the machine. Either before or right after the patient lies down in the supine position, set up any triggering devices or other monitoring equipment that is to be used.

8. Center the patient in a torso array coil or other form of dedicated radiofrequency coil at the hip(s) where the key information is desired. Generally, the top of the torso array coil is at the iliac crest and the bottom just below the greater trochanter.

9. Center positioning light at about the midpoint between the anterior superior iliac spine and the symphysis pubis and put him or her into the center of the magnet. This usually falls to the center of the torso array coil.

   Once this step has been performed, so long as the patient does not move on the table, the table itself can be moved and then replaced in the same position as before without jeopardizing the positioning of one scan relative to another.

10. Sedation is not needed for routine cases and should be reserved for severe claustrophobics.

Sequence 1: Rapid coronal scout

11. Run a scout series in the coronal plane using the parameters in Table A26.2.2. (Fig. A26.2.1).

Table A26.2.2 Coronal Scout

Patient position	Supine
Scan type	3-D short T_R gradient echo
Imaging plane (orientation)	Coronal
Central slice or volume center	Halfway between the anterior/superior iliac spine and the symphysis pubis
Echo time (T_E)	1.5 msec (or minimum)
Receiver bandwidth (RBW)	±32 kHz
Repeat time (T_R)	6 msec (or minimum)
Flip angle (FA)	30°
Fields of view (FOV_x, FOV_y)	480 mm, 480 mm
Resolution (Δx, Δy)	1.88 mm, 3.75 mm
Number of data points collected (N_x, N_y)	256, 128
Slice thickness (Δz)	10 mm
Number of slices	15–20
Slice gap	0 mm
Number of excitations (NEX)	2
Number of acquisitions (N_{acq})	1
Swap read and phase encoding	No
Read direction	Right–left
Slice locations	From above iliac crest to below greater trochanter
Flow compensation	No
No phase wrap (NPW)	No
Chemical saturation	No
Spatial saturation	No
Scan time	~23–31 sec (depends on size of patient)

Figure A26.2.1 A representative slice from the coronal series obtained using the parameters listed in Table A26.2.2.

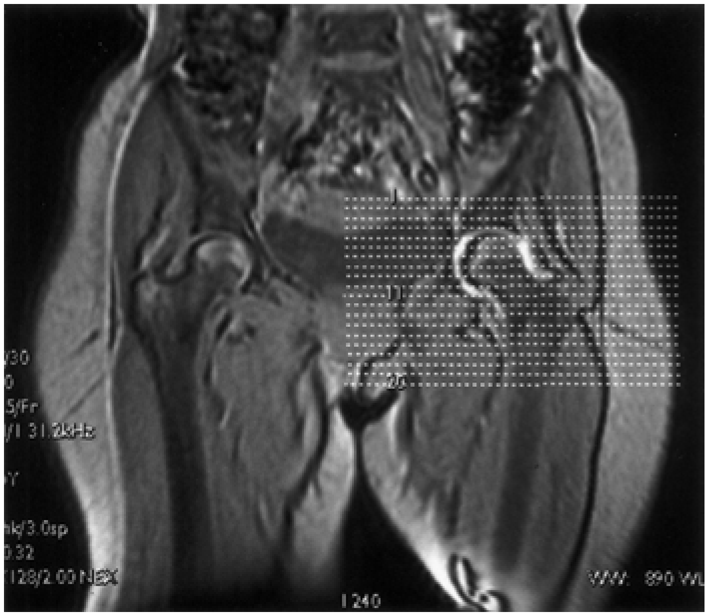

Figure A26.2.2 An image from coronal scout series with locations for the images of both of the following transverse series (sequences 2 and 5) indicated.

Table A26.2.3 Transverse Fat-Saturated T_1-Weighted FSE

Patient position	Supine
Scan type	Fast spin echo
Imaging plane (orientation)	Transverse
Central slice or volume center	Centered on the hips
Echo time (T_E)	~20 msec (second echo of the echo train set at two times the minimum T_E as the effective echo time)
Receiver bandwidth (RBW)	±32 kHz
Echo train length (ETL)	4
Repeat time (T_R)	600–800 msec
Flip angle (FA)	90° (or default)
Fields of view (FOV_x, FOV_y)	200–240 mm, 200–240 mm
Resolution (Δx, Δy)	0.78–0.94 mm, 1.04–1.25 mm
Number of data points collected (N_x, N_y)	256, 192
Slice thickness (Δz)	4 mm
Number of slices	25–30
Slice gap	0.5 mm
Number of excitations (NEX)	3
Number of acquisitions (N_{acq})	2 (interleaved series)
Read direction	Right–left
Slice location	From posterior to the SI (sacroiliac) joints to anterior to symphysis pubis—include all areas with Gd contrast agent
No phase wrap (NPW)	Yes
Chemical saturation	Yes (fat)
Spatial saturation	No
Scan time	~3 min (depends on T_R)

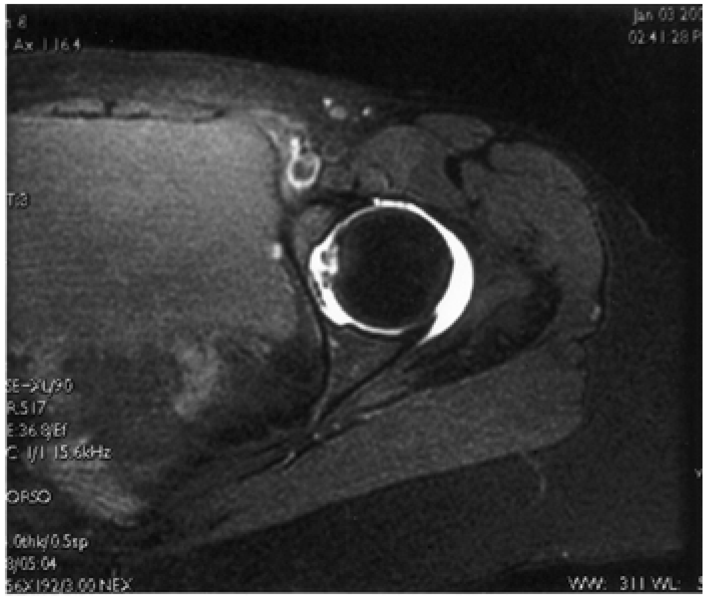

Figure A26.2.3 A representative image from the transverse, fat-saturated, T_1-weighted FSE sequence obtained with parameters listed in Table A26.2.3.

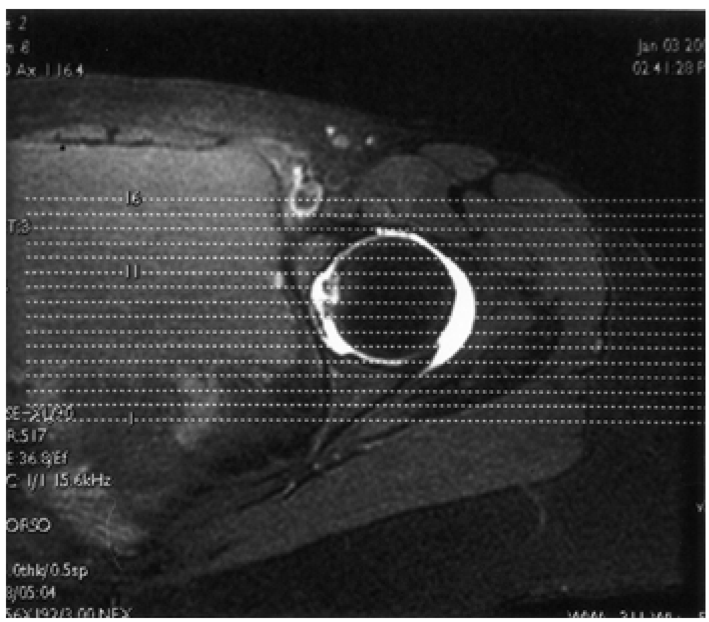

Figure A26.2.4 An image from the transverse, fat-saturated, T_1-weighted FSE sequence with locations for coronal series (sequence 3) indicated.

Table A26.2.4 Coronal Fat-Saturated T_1-Weighted FSE

Patient position	Supine
Scan type	Fast spin echo
Imaging plane (orientation)	Coronal
Central slice or volume center	Centered on the hip
Echo time (T_E)	~20 msec (second echo of the echo train set at two times the minimum T_E as the effective echo time)
Receiver bandwidth (RBW)	±32 kHz
Echo train length (ETL)	4
Repeat time (T_R)	600–800 msec
Flip angle (FA)	90° (or default)
Fields of view (FOV_x, FOV_y)	200–240 mm, 200–240 mm
Resolution (Δx, Δy)	0.78–0.94 mm, 1.04–1.25 mm
Number of data points collected (N_x, N_y)	256, 192
Slice thickness (Δz)	4 mm
Number of slices	25–30
Slice gap	0.5 mm
Number of excitations (NEX)	3
Number of acquisitions (N_{acq})	2 (interleaved series)
Read direction	Superior–inferior
Slice location	From just anterior to the hip to just posterior
No phase wrap (NPW)	Yes
Chemical saturation	Yes (fat)
Scan time	~3 min (depends on T_R)

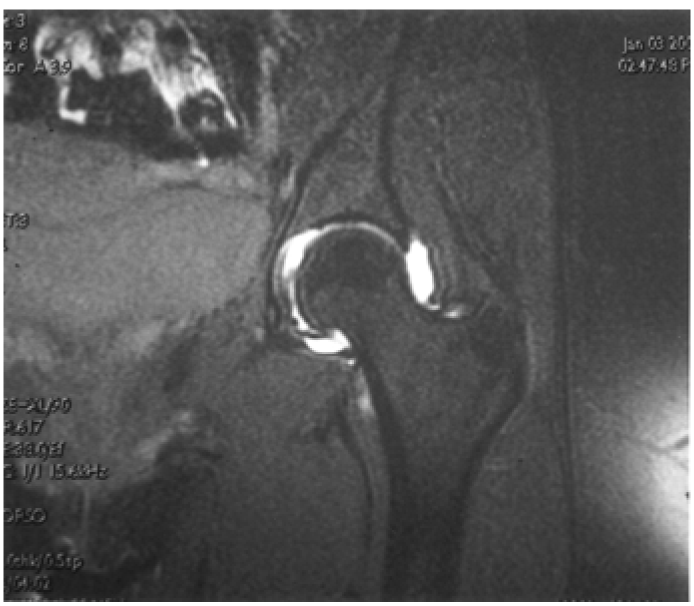

Figure A26.2.5 A representative image from the coronal, fat-saturated, T_1-weighted FSE sequence obtained with parameters listed in Table A26.2.4.

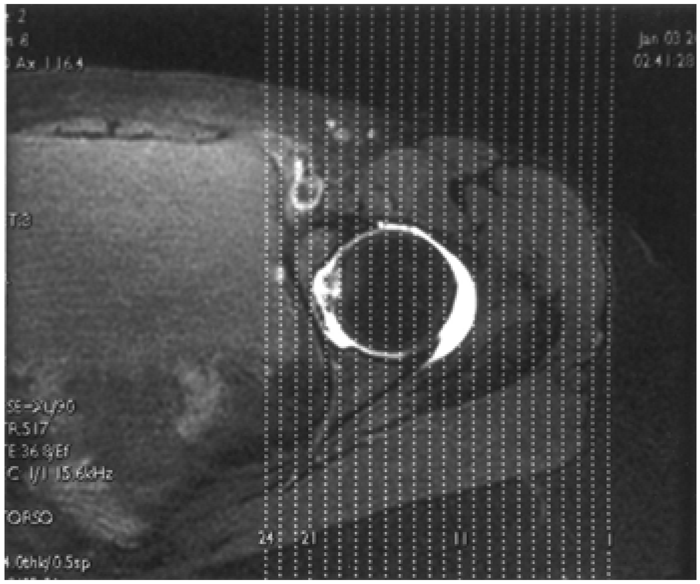

Figure A26.2.6 An image from the transverse, fat-saturated, T_1-weighted FSE sequence with locations for sagittal series (sequence 4) indicated.

Table A26.2.5 Sagittal Fat-Saturated T_1-Weighted FSE

Patient position	Supine
Scan type	Fast spin echo
Imaging plane (orientation)	Sagittal
Central slice or volume center	Centered on the hip
Echo time (T_E)	~20 msec (second echo of the echo train set at two times the minimum T_E as the effective echo time)
Receiver bandwidth (RBW)	±32 kHz
Echo train length (ETL)	4
Repeat time (T_R)	600–800 msec
Flip angle (FA)	90° (or default)
Fields of view (FOV_x, FOV_y)	200–240 mm, 200–240 mm
Resolution (Δx, Δy)	0.78–0.94 mm, 1.04–1.25 mm
Number of data points collected (N_x, N_y)	256, 192
Slice thickness (Δz)	4 mm
Number of slices	25–30
Slice gap	0.5 mm
Number of excitations (NEX)	3
Number of acquisitions (N_{acq})	2 (interleaved series)
Read direction	Superior–inferior
Slice location	From just medial to the acetabulum to the lateral margin of the surrounding muscles
No phase wrap (NPW)	Yes
Chemical saturation	Yes (fat)
Scan time	~3 min (depends on T_R)

Figure A26.2.7 A representative image from the sagittal, fat-saturated, T_1-weighted FSE sequence obtained with parameters listed in Table A26.2.5.

Sequence 2: Transverse T_1-weighted, fat saturated, FSE

12. Use scout (coronal) images to prescribe transverse images (Fig. A26.2.2). Run a transverse, fat-saturated, T_1-weighted FSE sequence using the parameters given in Table A26.2.3 (Fig. A26.2.3).

The rationale for using FSE sequences with the second echo of the echo train set at two times the minimum T_E as the effective T_E was explained above. If the gradient strength is not sufficient to permit a T_E of ≤30 msec, a conventional spin echo sequence with the minimal T_E achievable on the system should be employed. T_R must be sufficiently short to ensure T_1-weighting.

Sequence 3: Coronal T_1-weighted, fat-saturated, FSE

13. Use previously obtained transverse images to prescribe coronal images (Fig. A26.2.4). Run a coronal, fat-saturated, T_1-weighted FSE sequence using the parameters given in Table A26.2.4 (Fig. A26.2.5).

This sequence is identical to sequence 2 except for the orientation.

Sequence 4: Sagittal T_1-weighted, fat-saturated, FSE

14. Use previously obtained transverse images to prescribed sagittal images (Fig. A26.2.6). Run a sagittal, fat-saturated, T_1-weighted FSE sequence using the parameters given in Table A26.2.5 (Fig. A26.2.7).

Table A26.2.6 Transverse T_2-Weighted Fat-Saturated Fast-Spin Echo

Patient position	Supine
Scan type	2-D fast-spin echo
Imaging plane (orientation)	Transverse
Central slice or volume center	Centered on the hip
Echo time (T_E)	90 msec
Receiver bandwidth (RBW)	±16 kHz
Echo train length (ETL)	8
Repeat time (T_R)	6000 msec
Flip angle (FA)	90° (or default)
Fields of view (FOV_x, FOV_y)	380 mm, 380 mm
Resolution (Δx, Δy)	1.48 mm, 1.98 mm
Number of data points collected (N_x, N_y)	256, 192
Slice thickness (Δz)	5 mm
Number of slices	30–40 (depends on T_R)
Slice gap	1 mm
Number of excitations (NEX)	1
Number of acquisitions (N_{acq})	2
Swap read and phase encoding	Yes
Read direction	Anterior–posterior
Slice location	From above iliac crests to below lesser trochanters
No phase wrap (NPW)	Yes
Chemical saturation	Yes (fat)
Spatial saturation	Yes (superior and inferior)
Scan time	~5 min (depends on T_R)

Sequence 5: Transverse, fat-saturated, T_2-weighted FSE

15. Use scout (coronal) images to prescribe transverse images (Fig. A26.2.2). Run a transverse, fat-saturated, T_2-weighted FSE sequence using the parameters given in Table A26.2.6. (A representative image can be seen as Fig. A26.1.7.)

COMMENTARY

Background Information

Acetabular labral tears are an uncommon but significant cause of hip pain that is amenable to surgical treatment. They are often accompanied by a snapping sound but this is also seen with other disorders of the hip.

Critical Parameters and Troubleshooting

The authors believe that the use of a high-field (i.e., ≥1 T) system and MR arthrography in conjunction with surface or array coils to obtain the highest possible resolution are important factors to demonstrate labral abnormalities. However, there have been no studies to prove that any of these factors are critical to obtain accurate diagnoses.

The rationale for the use of the second echo of the echo train for the short-T_E, fat-saturated, FSE sequence with this second echo set to the smallest value possible (i.e., two times the minimum echo) is discussed above. Note that the authors use a 32-kHz bandwidth to help achieve this minimum effective T_E. If the T_E cannot be kept at ≤30 msec, it is probably better to used a conventional spin echo sequence.

The number of excitations will depend on the particular coil used, the FOV, the bandwidth, and the size of the patient. For heavy-set patients, choose the largest FOV in the given range (240 mm) or even increase it up to 280 mm. An increased number of excitations (i.e., more than the NEX = 3 given above) may be used in conjunction with, or in place of, the

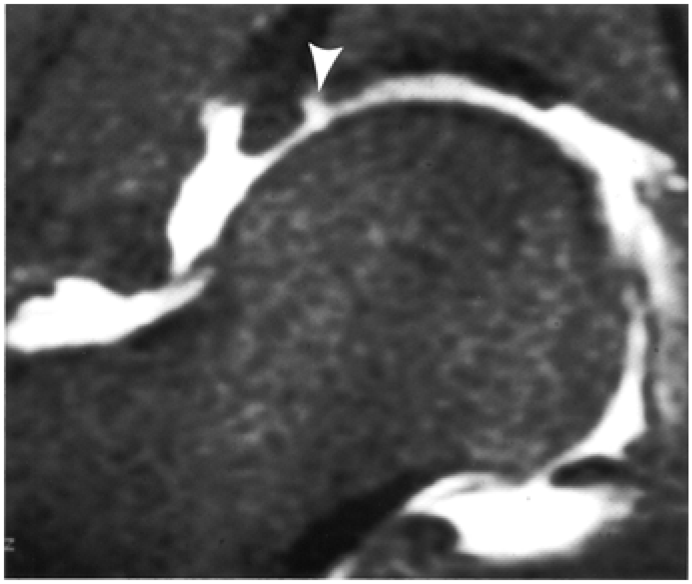

Figure A26.2.8 A coned down, coronal fat-saturated, T_1-weighted FSE image of the right hip demonstrates the presence of a tear of the superior acetabular labrum (arrowhead).

increased FOV. The technical factors given above work well on the system described in this unit but may have to be altered for different systems.

Anticipated Results

A small number of cases of surgically confirmed acetabular labral tears have been reported in the radiology literature (Czerny et al., 1999). The anterosuperior segment of the labrum is the region most commonly involved by a tear. Multiple different appearances of tears diagnosed with MR arthrography have been described and include absence, fragmentation, linear defects, clefts, and intrasubstance high signal (Fig. A26.2.8). It is of interest that similar appearing morphologic abnormalities have been described in the labrum on nonarthrographic studies in asymptomatic subjects. They are noted to occur with increased frequency in older subjects and most commonly in the anterosuperior segment. Because these subjects were not studied with arthrography, the relationship between these findings and those seen at arthrography is unclear. Nevertheless, it does cast some doubt on the clinical significance of what have been considered to represent labral tears.

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