Direct MR Arthrography of the Hip with Leg Traction: Feasibility for Assessing Articular Cartilage

Eva Llopis[1]
Luis Cerezal[2]
Ara Kassarjian[3]
Victoria Higueras[1]
Ernesto Fernandez[4]

OBJECTIVE. Hip arthrography is an accurate diagnostic method for evaluation of the peripheral compartment, but its depiction of cartilage lesions is moderate. The purpose of this study was to add leg traction to MR arthrography of the hip to test its effect on visualization of cartilage surfaces.

CONCLUSION. Hip MR arthrography with leg traction is a technically feasible and safe procedure that improves visualization of the femoral and acetabular cartilage surfaces.

The hip joint is a substantial challenge to radiologists for a variety of reasons. The critical structures, mainly the acetabular labrum and the femoral and acetabular cartilage, are small, requiring high-resolution imaging for adequate depiction of normal and pathologic anatomic features. Chondral lesions are an important source of hip joint pain, and the extent or thickness of the cartilage injury is the most decisive predictor of surgical outcome [1, 2]. The morphologic characteristics of the hip joint—the ball-in-socket configuration with permanent contact between the articular surfaces and small intraarticular volume, the strong articular capsule, and the tightness of the ligaments (especially the iliofemoral ligament) and surrounding muscles—make separation between the femoral and acetabular cartilage difficult. Moreover, the limited value of surface coils due to the deep position of the cartilage within the body adversely affects image quality.

MR arthrography of the hip has been shown accurate for evaluating the acetabular labrum and peripheral compartment. However, the accuracy in assessing lesions of the central cartilage is only moderate [3, 4]. The cartilage of the acetabulum and femoral head often cannot be seen as distinct entities despite the use of an intraarticular contrast agent, and therefore small lesions can be difficult to visualize [3, 5–8]. At arthroscopy, a distinction is made between the easily accessible peripheral compartment, which comprises unloaded femoral cartilage, femoral neck, and synovial folds, and the tight central compartment, which includes the loaded hyaline cartilage of the femur and acetabulum, acetabular fossa, and teres ligament [1, 9]. The labrum separates the two compartments. Arthroscopic evaluation of the hip is a two-step procedure: flexion without traction for evaluation of the peripheral compartment and extension with traction for evaluation of the central compartment [10, 11]. Distraction and distention are used to visualize cartilage in the central compartment, including the more central part of the labrum [2, 12, 13].

Manual traction during radiography has been used to make a diastasis between the femoral head and the acetabulum [14, 15]. Continuous leg traction has been used to improve visualization of acetabular labral tears during MR arthrography after IV rather than articular administration of a contrast agent. To the best of our knowledge [13, 16], no previous studies have explored the potential advantage of combining intraarticular administration of a contrast agent and leg traction. The purpose of our study was to determine the feasibility of leg traction combined with MR arthrography and the effect of the technique on visualization of cartilage surfaces.

Subjects and Methods

Informed consent was obtained from each patient, and the study was approved by the institutional review boards at two hospitals. The study group consisted of 48 patients consecutively referred from December 2005 through December 2006 for hip MR arthrography for the evaluation of groin pain. Prospective MR arthrographic examinations were performed after application of leg traction while the subjects were on the MRI

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[1]Department of Radiology, Hospital de la Ribera, Carretera de Corbera km1, Alzira, Valencia, 46600, Spain. Address correspondence to E. Llopis.

[2]Instituto Radiologico Cantabro, Clinica Mompia, Santander, Spain.

[3]Department of Radiology, Division of Musculoskeletal Radiology, Massachusetts General Hospital, Boston, MA.

[4]Department of Orthopedics, Hospital de la Ribera, Valencia, Spain.

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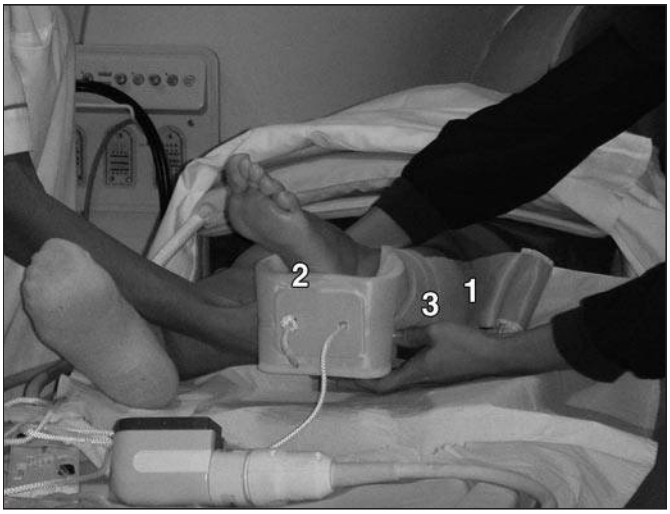

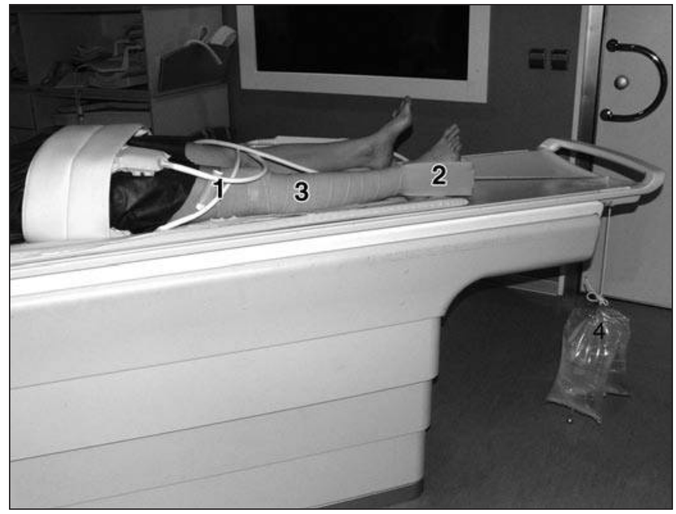

Fig. 1—Traction device.
A and **B,** Photographs show lateral adhesive straps (1) fixed parallel to thigh, leaving 5-cm distance between sole and plate (2), and fixed with bandage (3). System is loaded (**B**) to 6 kg (4).

table. Exclusion criteria were previous surgery, inadequate hip distention due to leakage from the joint, and pain related to injection. Two patients in the study group underwent bilateral hip MR arthrography, so 50 MR arthrographic examinations of the hip were performed. All patients had undergone conventional bilateral hip MRI.

The records of 10 aged-matched patients who had undergone conventional MR arthrography for evaluation of groin pain before December 2005 were retrieved from our database. The imaging protocol was the same as for the 48 patients except for use of the manual traction and load device. The 10 patients made up the control group. The characteristics of the control group were similar to those of the study group. The mean age of the control group was 35 years (range, 21–46 years).

Arthrography was performed by one of two musculoskeletal radiologists, who had 5 and 7 years of experience in MR arthrography of the hip. The only difference in procedure between the study and control groups was that traction was not applied to the control group. The patients were placed supine on the fluoroscopic table. The lower extremity was held in neutral or slight internal rotation with the toes taped together to bring the femoral neck into the coronal plane. The skin was prepared in the usual sterile manner, disinfected with iodine solution, and covered with sterile drapes. Arthrography was performed with a 22-gauge needle in 47 hips and a 20-gauge needle in three hips. A 22-gauge needle was used for the control group. Local anesthesia with 4 mL of 2% lidocaine (Lidocaina, Braun) was injected at the skin entrance site. An oblique approach from the intertrochanteric line toward the femoral neck junction was used. The intraarticular position of the needle tip was checked with 1–2 mL of iodinated contrast material (amidotrizoate acid, Trazograf, Juste). A mean of 15 mL (range, 10–18 mL) of standard dilute 0.01-mmol gadopentetate dimeglumine (Omniscan, GE Healthcare) solution was injected. The solution is made with 12 mL of 0.9% saline solution, 4 mL of lidocaine, and 4 mL of iodine. The cocktail was injected under fluoroscopic guidance until a change in resistance, pain, or leakage occurred. The patients then were transferred to the MRI suite.

In the study group, leg traction was applied on the MRI table with a standard MRI-compatible orthopedic skin traction device (Noba-extensions-verband, Noba). We decided to use less traction than is commonly used at arthroscopy (10% of body weight) and arbitrarily used 6 kg, consisting of two 3-kg bags of saline solution. Before we selected the load, we tried other loads. When we increased the load to 6 kg, the separation achieved with manual traction was maintained. The traction device consists of two lateral adhesive straps fixed parallel to the leg from the ankle through the patellar level. A 5-cm distance between the sole of the foot and the traction plate is left to allow easy handling of the ropes used for traction. A conventional bandage fixes the device (Fig. 1). The time required to apply the traction device was recorded. In 15 patients (15 hips) in the study group, two MRI sequences were performed without traction before traction was applied. Manual traction was applied by the radiologist before the load was applied. Traction was continuous throughout the MRI study.

We used a 1.5-T MRI system (Achieva 1.5 T, Philips Medical Systems), with a phased-array body coil positioned for unilateral hip imaging. For the two patients who needed bilateral hip imaging, a separate session was used to image the second hip. Fat-saturated T1-weighted MR images were obtained in the coronal, axial, and sagittal oblique planes along the long axis of the femoral neck with the following parameters: TR/TE, 450/15; matrix size, 256 × 512; section thickness, 3 mm; interslice gap, 0.3 mm; number of signals per data line acquired, 3; field of view, 16 cm^2. A non-fat-saturated T1-weighted sequence with the foregoing parameters was performed in the oblique sagittal plane. A coronal proton density–weighted sequence (1,585/35) was performed with the matrix size, slice thickness, and spacing used for the previous images. The two additional sequences performed before application of traction on 15 hips were sagittal T1-weighted imaging and coronal proton density–weighted imaging with the same parameters as for images obtained with traction.

MR images were evaluated by consensus of two of four subspecialty musculoskeletal radiologists with 7, 9, 10, and 12 years of experience in skeletal imaging. The criteria were ability to visualize the femoral and acetabular cartilage surfaces as distinct entities and to measure the distance between these surfaces. The maximum distance between femoral and acetabular cartilage surfaces was measured on the central image from coronal and sagittal oblique imaging with the measuring tool on the workstation. Cartilage lesions were classified as subchondral (normal cartilage surfaces), osteochondral (disrupted cartilage extended to the subchondral bone), or pure chondral and fraying of chondral surface, partial-thickness defect, or full-thickness (> 50%) defect. Degenerative

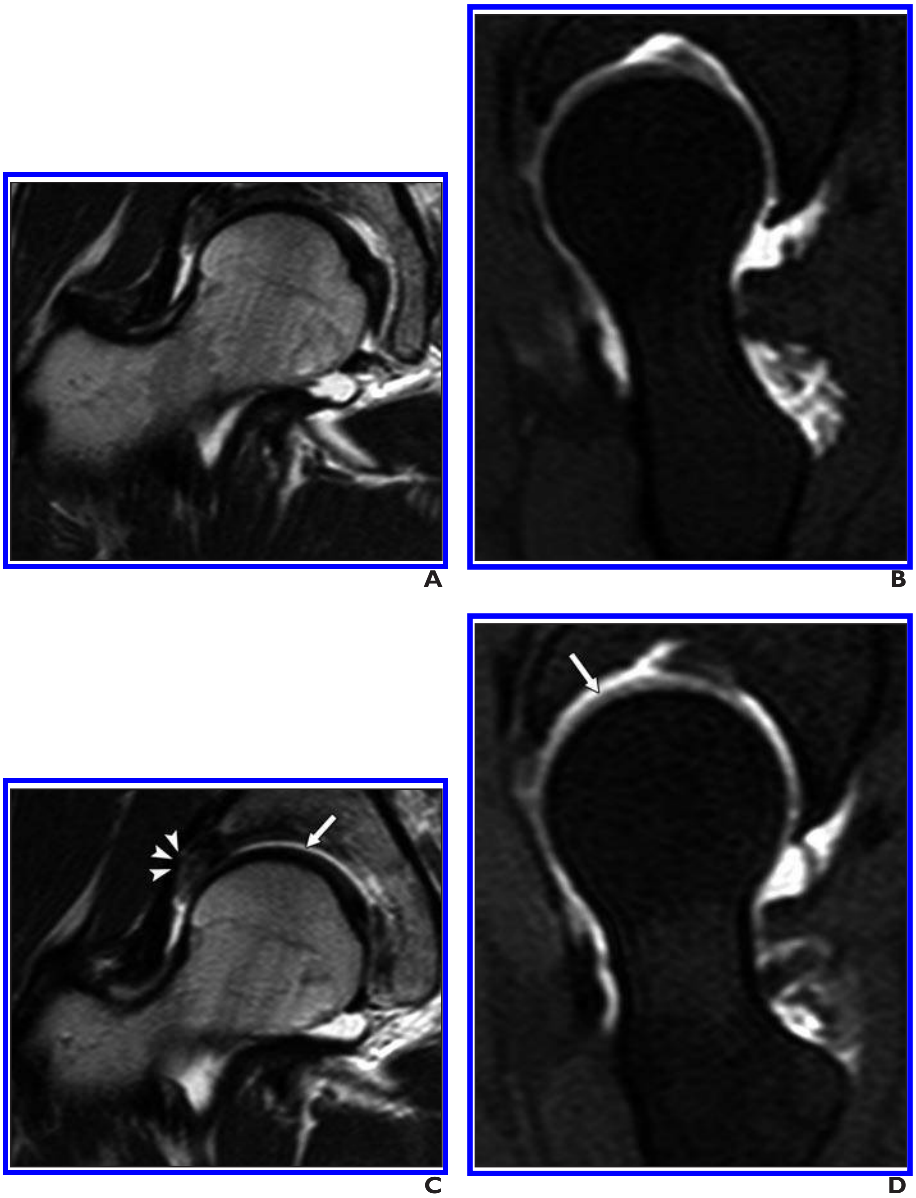

Fig. 2—23-year-old male tennis player. MR arthrograms with and without traction show how well cartilage surfaces are depicted with traction.
A and **B,** Coronal proton density–weighted fast spin-echo MR arthrogram without traction (**A**) and oblique sagittal fat-suppressed T1-weighted fast spin-echo image (**B**) readily show labral degeneration and tear, but femoral and acetabular cartilages are not evident as separate structures.
C and **D,** Traction proton density–weighted fast spin-echo (**C**) and fat-suppressed T1-weighted (**D**) images corresponding to **A** and **B** show separation (*arrow*) between cartilage surfaces, which allows assessment of cartilage defects. Labrum tear (*arrowheads*, **C**) is evident.

changes seen as bony osteophytes and joint space narrowing were documented.

All patients in the study group were instructed to inform the radiologist if they experienced any discomfort during application of traction or during MRI data acquisition. Pain was graded with a semiquantitative scale: none, mild, moderate, and severe. All patients were given the option to request discontinuation of traction at any point during the examination. After the procedure, all patients in the study group were questioned regarding presence of discomfort, pain, and neurologic symptoms involving the leg to which traction was applied. For patients with symptoms, the questions were repeated during a telephone conversation 48 hours after MRI.

Results

The mean age of the study group was 36 years (range, 20–49 years), and 28 patients were men. Intraarticular injection of contrast material was achieved in all cases. The interval between arthrography and MRI was less than 20 minutes in all cases. Three patients were excluded because of inadequate intraarticular distention with the contrast agent. Two hips in the study group exhibited small normal communication between the hip joint and the iliopsoas bursa.

The average time it took to place the leg traction device on the MRI table was 4 minutes (range, 3–8 minutes). We detected no complications related to the procedure. None of the patients requested termination of traction or reported pain or neurologic symptoms during or immediately after the examination. The leg traction device was well tolerated by all patients. Five patients had mild problems related to arthrography that resolved within 48 hours without the need for intervention or medication.

The mean cartilage surface separation without traction in the 10 patients in the control group was 0.2 mm (range, 0–0.6 mm) in both the coronal and oblique sagittal planes. In two of these patients, the observers were able to differentiate femoral from acetabular cartilage.

With traction, in all patients in the study group except three who had early degenerative changes, the femoral and acetabular cartilage surfaces were seen as separate structures with contrast agent separating the two surfaces. The mean separation of the cartilage surfaces with traction was 1.7 mm (range, 0.6–3.8) mm. The mean distance in the coronal plane was 1.4 mm and in the oblique sagittal plane was 1.8 mm (Figs. 2 and 3).

In 15 hips (15 patients) imaged without and with traction, the mean distance between femoral and acetabular cartilages was 0.2 mm (range, not measurable to 0.4 mm) before traction. The distance increased an average of 1.5 mm (range, 0.75–3.8 mm) with traction (Figs. 4–6). In three hips in the study group, despite adequate intraarticular hip distention, insufficient separation of the joint cartilage was obtained for clear depiction of the two cartilage surfaces. Traction in these three patients was insufficient to achieve separation between the femoral and acetabular cartilages. These three patients had degenerative changes secondary to cam-type femoroacetabular impingement.

Maximal separation between the cartilage surfaces was typically along the superior

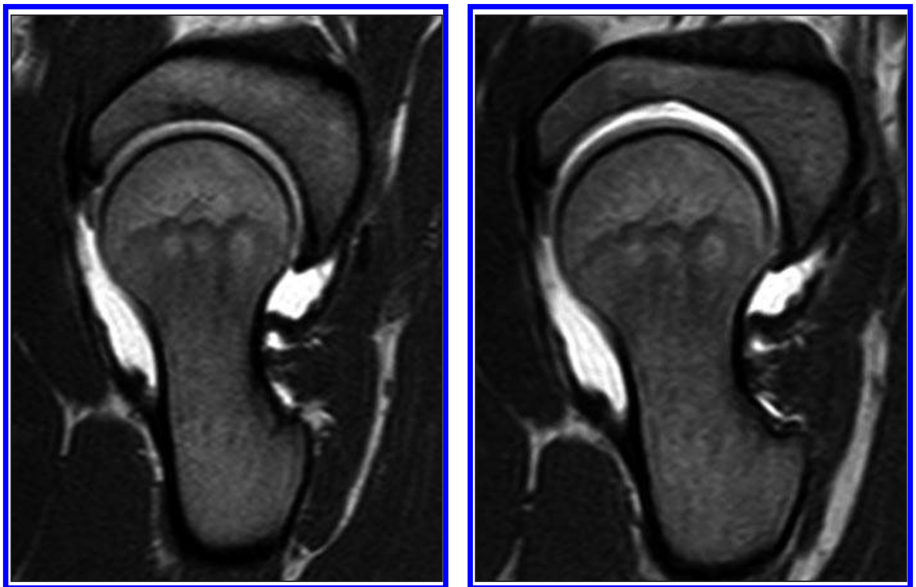
A B

Fig. 3—16-year-old female runner with unilateral left hip pain.
A and **B,** Oblique sagittal T1-weighted MR images without (**A**) and with (**B**) traction show marked distention of deep central compartment hip that allows differentiation of articular femoral and acetabular cartilages as separate structures.

portion of the hip joint and was better depicted in the oblique sagittal plane. In the study group, 20 patients had normal cartilage surfaces. Excluding the three patients with degenerative changes in whom traction was insufficient, 25 patients were found to have cartilage injuries. Femoral cartilage fraying was present in 17 patients, femoral pure chondral defects (three partial thickness, two full thickness) in five, femoral osteochondral lesions in three, femoral subchondral lesion in three, acetabular cartilage fraying in nine, acetabular pure chondral lesion (two partial thickness and four full-thickness defect) in six, and acetabular osteochondral lesion in eight patients. In the 15 patients imaged without and with traction, two pure femoral chondral lesions (one full thickness, one partial thickness) were seen only after traction. Eight possible lesions seen without traction were better characterized with traction. Of these eight, imaging with traction showed two instances of normal cartilage surfaces, five instances of femoral cartilage fraying, one instance of femoral subchondral lesion, and one instance of acetabular cartilage fraying.

Discussion

This study showed the potential advantage of applying manual traction followed by gentle leg traction during MR arthrography of the hip. Such traction produces enough space for the intraarticular contrast agent to enter the tight central compartment. This combination of contrast agent and additional space allows visualization of the cartilage surfaces as distinct entities. The study also showed that limited traction is well tolerated and can be applied in a short time without specialized equipment. The arbitrarily chosen 6 kg of traction was well within the traction force used during arthroscopy, and no adverse effects such as transient neuropraxia occurred. Only five patients mentioned a temporary increase in discomfort in the hip. There seems to be room for optimization; for instance, we used the same traction for men and women and independently of patient weight.

For 15 hips, images without and with traction were compared. The findings in these cases showed that traction and the ensuing mean increase in distance between femur and acetabulum of 1.5 mm make a difference. Identification of femoral and acetabular cartilages as distinct structures was possible only on images obtained during traction (Figs. 2 and 3). Results of comparison of the study group with the control group, who underwent only conventional MR arthrography, further support the value of traction. The mean distance between femoral and acetabular cartilages was not measurable in the control group and was an average of 1.7 mm in the study group. Also in this comparison, identification of the femoral and acetabular cartilages as distinct structures was the benefit of traction, facilitating characterization of cartilage lesions and increasing diagnostic confidence.

Distraction and the possibility of identifying the cartilaginous surfaces of the femur and acetabulum as separate structures were

Fig. 4—28-year-old man with right hip pain. Oblique sagittal T1-weighted image MR arthrogram shows large subchondral lesion without involvement of articular cartilage (*arrow*).

Fig. 5—40-year-old man with decreased internal rotation of left hip. Oblique sagittal T1-weighted MR arthrogram shows large osteochondral anterosuperior lesion extending to cartilage and small cartilage flap (*arrow*).

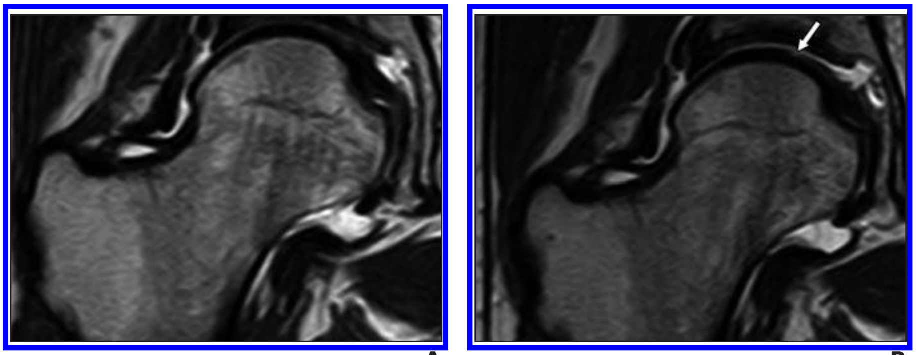

Fig. 6—37-year-old woman with right hip pain.
A and **B,** Coronal proton density–weighted fast spin-echo images without (**A**) and with (**B**) traction. Cartilage defect (*arrow*, **B**) is evident only after application of traction.

less feasible in patients with degenerative disease. The volume of contrast agent injected in these joints was less than in joints without degenerative changes.

Without the application of traction, the cartilage imaged is frequently a summation of the acetabular and femoral cartilages. As such, partial-thickness cartilage surface lesions can be difficult or impossible to see (Figs. 4–6). In addition, if a partial-thickness lesion is seen, it may be difficult to tell with certainty whether the lesion involves the acetabular or the femoral cartilage. Extent or thickness of cartilage involvement has been shown to be the most powerful predictor of surgical outcome. Moreover, knowing which cartilage surface is involved and the size of the chondral defect have important therapeutic implications, because newer femoral procedures, such as resurfacing, are increasingly being used [2, 17]. It remains to be proved whether clinical application of the traction technique will result in increased accuracy in detection and characterization of cartilage lesions and have clinical and surgical implications. These factors should be studied in future trials.

This study had limitations. First, the number of subjects was small. Second, the effect of traction on visualization and the accuracy of diagnosis of lesions of intraarticular structures, such as the labrum, were not evaluated. We compared visibility of only a few lesions without using a reference diagnosis. In summary, hip MR arthrography with leg traction is a technically feasible and safe procedure that improves visualization of the femoral and acetabular cartilage surfaces.

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