

The role of multidetector CT arthrography in the investigation of suspected intra-articular hip pathology

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ABSTRACT. The aim of this study was to evaluate the role of multidetector CT (MDCT) arthrography in the diagnosis of intra-articular hip pathology. A retrospective review of 96 patients who had undergone CT hip arthrography was performed. Data regarding the presence of a labral tear, paralabral cyst, chondral loss, acetabular version, femoral morphology and fibrocystic change were collected. We detected 28 labral tears (24 anterior, 2 anterolateral, 1 lateral and 1 posterolateral). An abnormal labral-chondral transitional zone was seen in 9 patients and 4 patients had surface labral fraying. We identified three paralabral cysts. Acetabular cartilage loss was detected in 45 and femoral cartilage loss in 9 patients. An abnormal anterior femoral head and neck junction was present in 18 hips and fibrocystic change in 8. Acetabular retroversion was present in 11 hips. 63 sets of patient notes were reviewed, of which 49 were in-patients with abnormal MDCT arthrogram findings. Surgical correlation was available in 27 patients. There was a discrepancy between the findings of a labral tear in one patient (false negative, 90% sensitivity and 100% specificity) and the presence of acetabular cartilage loss (88% sensitivity and 100% specificity) and femoral cartilage loss (94% sensitivity and 100% specificity) in three patients. MDCT arthrography affords accurate detection of intra-articular hip pathology.

Received 1 May 2009
Revised 5 August 2009
Accepted 18 August 2009

DOI: 10.1259/bjr/76751715

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Radiology

The investigation of suspected intra-articular hip pathology is challenging. Arthroscopy represents the gold standard but is invasive, necessitates a general anaesthetic and is best reserved for patients in whom concomitant therapeutic intervention is to be undertaken. Much of the radiology literature has focused on the use of MR arthrography of the hip to detect labral and cartilage pathology [1–5]. A number of groups have also studied the role of non-contrast MRI in the detection of labral tears associated with femoroacetabular impingement and acetabular dysplasia [6–9]. Both non-contrast MRI and MR arthrography have limitations in terms of spatial resolution, which can make the detection of subtle labral and cartilage pathology challenging [4].

Modern spiral multidetector CT (MDCT) technology allows submillimetre spatial resolution and has revitalised interest in the role of CT arthrography in the wrist, shoulder, knee, elbow and ankle [10–17]. There are few published data on the utility of this technique in the investigation of intra-articular hip pathology. Several studies have investigated the ability of MDCT arthrography to assess cartilage loss in the hip and have demonstrated that its accuracy is equal to, or can outperform, MR arthrography [18–20]. There are limited reports regarding the ability of MDCT arthrography to assess labral pathology [9]. The aim of this study was to evaluate

the role of MDCT arthrography in the diagnosis of intra-articular hip pathology in a consecutive group of patients.

Methods and materials

A retrospective review of 96 consecutive patients (37 male, 59 female; age range 10–65 years, mean age 38 years) who had undergone CT arthrography of the hip over a 20-month period was performed. The predominant patient complaint was of hip or groin pain and all had been assessed by a specialist hip surgeon prior to referral for imaging. Any history of a pre-existing condition such as Perthe's disease or hip dysplasia was recorded, as well as the nature of any previous hip or pelvic surgery. The predominant clinical articular diagnosis was a suspected labral tear with or without articular cartilage injury. Data regarding the presence and site of labral abnormality, paralabral cyst formation, presence and site of chondral loss, acetabular version, femoral head and neck morphology and the presence of fibrocystic change of the femoral head and neck junction were collected.

Pathology involving the labrum was subcategorised on the basis of the pattern of abnormality of the labrum. A labral tear was defined as contrast extension into the body of the labrum. A labral chondral transitional zone abnormality referred to contrast extension through the labral base at the attachment of the labrum to the acetabulum or acetabular rim. Finally, the presence of surface irregularity, fissuring or fraying of the labral

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margins was also commented upon. The location of the labral tear or labral chondral transitional zone abnormality was subdivided into thirds: anterior, lateral and posterior. If the lesion crossed these zones then it was termed anterolateral or posterolateral accordingly. Likewise, acetabular and femoral cartilage loss was defined using similar thirds; however, where cartilage loss was seen to involve multiple areas this was termed diffuse. Where typical appearances of a sublabral sulcus were identified (often posteriorly), this finding was considered a normal variant and data on this were not collected. Notes were available for review in 63 patients and a correlation between the clinical intervention (if any) and the CT arthrogram findings was performed. Institutional review board approval was not required for the retrospective analysis of cases performed in this study.

Procedure technique

Patient informed consent was obtained prior to arthrography. Arthrograms were performed using an anterolateral approach, under fluoroscopic guidance. Dilute iodinated contrast (10–12 ml; Omnipaque GE Healthcare, Uppsala, Sweden) was injected into the hip joint (50:50 mix of 240-strength iodinated contrast and normal saline). The normal saline was replaced with 5–6 ml 0.5% bupivacaine if a diagnostic injection was required, and the patient was given a pain diary to assess response. The hip joint was briefly passively exercised before a block axial acquisition (Siemens four-channel MDCT, Siemens, Erlangen, Germany) at 0.6-mm intervals was obtained. The study was then reported by a single fellowship-trained musculoskeletal radiologist from a workstation using axial, axial oblique, coronal and sagittal reconstructions.

Results

Out of a total of 96 patients, 69 (71%) had abnormal findings. Table 1 demonstrates the range and site of pathology detected by MDCT arthrography. Pre-existing conditions included developmental dysplasia of the hip (14 patients), Perthe's disease (3 patients), previous hip trauma (2 patients) and previous triple pelvic osteotomy (3 patients). Table 2 further subcategorises the findings of Table 1 by demonstrating the labral lesions and cartilage loss patterns seen in specific conditions. Patient notes were available for review for 63 (66%) patients, 49 (51%) of whom had abnormal MDCT arthrograms. Of these, 27 (55%) patients had operative intervention, with the remainder being treated conservatively. A total of 17 (63%) patients underwent hip arthroscopy and 10 (37%) had open surgery. Open surgical procedures included hip resurfacing (4), femoral de-rotational osteotomy (2), triple pelvic osteotomy (2) and surgical dislocation and debridement (2). In the patients who had undergone arthroscopy, there was one false-negative report of a labral tear and nine true positives (90% sensitivity and 100% specificity, 100% positive predictive value and 86% negative predictive value). Slight under-reporting of cartilage loss was seen in two

patients and over-reporting of chondral loss in one. Table 3 details these discrepancies further. These findings give MDCT a sensitivity of 88% and specificity of 100% for acetabular cartilage loss detection and a sensitivity of 94% and specificity of 100% for femoral cartilage loss. There was good correlation between the remaining 11 arthroscopies and the arthrogram findings. Abnormal osseous protuberances were detected by MDCT in five patients and were successfully debrided in four cases; one lesion could not be reached during arthroscopy.

Discussion

With the development of MDCT technology, MDCT arthrography is becoming an increasingly useful modality in the detection of joint pathology. Multiple studies have demonstrated excellent diagnostic results when used in the wrist, shoulder, elbow and knee [10–17]. There is, however, little published literature regarding MDCT arthrography of the hip in the assessment of intra-articular hip pathology.

Detection of hip labral pathology has traditionally presented a diagnostic challenge. The majority of studies have focused on the use of MRI, using both non-contrast and direct arthrographic techniques. Using a high-resolution surface-coil technique, James and co-workers [6, 7] reported that non-contrast MRI has good ability to detect labral and chondral pathology in both femoroacetabular impingement and acetabular dysplasia. Multiple studies have also reported excellent results for the detection of labral pathology using direct MR arthrography [3, 21]. It has, however, been recognised that the lack of spatial resolution of MRI can make the detection of small labral tears difficult. In a study performed by Keeney et al [2], 102 patients with clinical symptoms indicative of a labral tear underwent MR arthrography and subsequent arthroscopy. MR arthrography was found to have a sensitivity of 71%, specificity of 44%, positive predictive value of 93%, negative predictive value of 13% and accuracy of 69% for the detection of labral pathology. The authors concluded that, although MR arthrography was an excellent positive predictor of labral pathology, it had limited sensitivity and a negative study could not exclude important pathology amenable to treatment. Further studies have assessed the usefulness of radial reformatted images to improve the sensitivity of labral tear detection. Chan et al [22] evaluated 16 patients with suspected labral tear by MR arthrography with radial reformatted images and used the arthroscopic findings as a reference; they demonstrated 100% sensitivity and 96% accuracy. However, more recent work by Yoon et al [23] found no difference in sensitivity in the detection of labral tears between radial reformats and standard MR arthrographic views.

CT arthrography of the hip is not a new technique, but the improved resolution of MDCT has made it a viable alternative to MRI. Nishii et al [9] recently investigated the ability of MDCT to assess disorders of the acetabulum and labrum in hip dysplasia in 41 patients using radial reformatted images. They compared imaging findings with those of arthroscopy in approximately

Table 1. The range and sites of pathology detected by MDCT arthrography

Pathology	Total patient number	Pathology location and patient number
Labral tears	28	Anterior 24 (86%) Anterolateral 2 (7%) Lateral 1 (3.5%) Posterolateral 1 (3.5%)
Abnormal labral surface fissuring and fraying (no definite labral tear defined by intralabral extension of contrast)	4	Anterior 2 (50%) Anterolateral 1 (25%) Lateral 1 (25%)
Abnormal labral chondral transitional zone (no extension of tear into labral body)	9	Anterior 6 (67%) Anterolateral 1 (11%) Lateral 2 (22%)
Acetabular cartilage loss	45	Anterior 30 (67%) Anterolateral 5 (11%) Lateral 5 (11%) Diffuse 5 (11%)
Femoral cartilage loss	9	Anterior 5 (56%) Posterior 1 (11%) Diffuse 3 (33%)
Paralabral cysts	3	Anterior 1 Anterolateral 1 Lateral 1
Femoral head and neck junction osseous bump	18	
Fibrocystic change at femoral head and neck junction	8	
Acetabular retroversion	11	
Coxa vara	1	
Hypertrophy of the ligamentum teres	1	

MDCT, multidetector CT.

50% of patients. Excellent correlation was seen: the sensitivity, specificity and accuracy of CT arthrography for the detection of labral tears was found to be 97%, 87% and 92%, respectively. In the current study, we used similar criteria for the detection of labral tears with CT to those used in MR arthrography, namely extension of contrast into the labral substance or between the labrum and acetabulum as well as alteration of the normal smooth contour of the labrum [1, 3, 24]. We aimed to distinguish between a labral tear where contrast extension was seen into the labrum itself from lesions involving the acetabular rim/margin (*i.e.* the labral chondral transitional zone) and those that showed surface changes to the labrum. By doing this we were

able to show differences in the patterns of labral tears when secondary to developmental dysplasia of the hip *vs* femoroacetabular impingement. In the latter condition, we have shown the injury frequently occurs at the labral-chondral transitional zone, as demonstrated previously [6]. We have demonstrated excellent correlation between the MDCT arthrogram findings and those of arthroscopy. The majority of labral tears (86%) were detected in the anterior labrum (Figure 1), nine tears were confined to the labral chondral transitional zone (Figure 2) and three paralabral cysts (Figure 3) were seen.

Recent work suggests that MDCT arthrography has a sensitivity equal to, or better than, that of MR arthrography for the detection of cartilage loss in the hip [9, 18, 20].

Table 2. The degree of labral and chondral pathology associated with specific conditions

Condition (patient number)	Labral tear	Labral chondral transitional zone	Acetabular cartilage loss	Femoral cartilage loss
DDH (14 patients)	10 patients: 8 anterior; 1 anterolateral; 1 lateral	1 anterior	11 patients: 9 anterior; 1 lateral; 1 diffuse	3 patients: 1 anterior; 1 lateral; 1 posterior
Perthe's disease (3 patients)	2 tears anterior	0	3 patients: 2 anterior; 1 diffuse	1 diffuse
Acetabular retroversion (11 patients)	5 patients: 4 anterior; 1 anterolateral	1 anterior	5 patients: 5 anterior	0
FAI (20 patients)	8 patients: 7 anterior; 1 anterolateral	6 patients: 5 anterior; 1 anterolateral	15 patients: 11 anterior; 3 anterolateral; 1 anterior and posterior	2 patients: 1 anterior; 1 central

DDH, developmental dysplasia of the hip; FAI, femoro-acetabular impingement

Table 3. Patients in whom discrepancy existed between the surgical findings and the MDCT arthrogram

Surgical findings	MDCT arthrogram findings
Badly frayed anterolateral labrum	Normal labrum
No impingement	Fibrocystic changes at femoral head and neck junction
Torn anterior labrum	Torn anterior labrum
Anterior cam lesion	Fibrocystic change
Very early acetabular chondral delamination	Normal femoral and acetabular cartilage
Anterolateral labral tear	Anterolateral labral tear
Mild acetabular cartilage loss	Well-preserved femoral and acetabular cartilage
Cam lesion	Cam lesion
Normal labrum	Intact labrum
Patchy femoral and acetabular cartilage loss	Anterior acetabular cartilage loss

MDCT, multidetector CT. Patients in whom discrepancy existed between the surgical (arthroscopic) and the MDCT arthrogram.

It has been suggested that the curved articular surface and thin layer of hyaline articular cartilage found in the hip, compared with the knee, can make cartilage loss more difficult to detect with the somewhat limited spatial resolution of MRI. In addition, as the hip is situated deep in the body, loss of signal-to-noise ratio occurs, which is compounded by the lack of an effective surface coil [4]. MDCT allows for high-resolution multiplanar reformatted images to be obtained, which enable excellent assessment of both femoral (Figure 4) and acetabular cartilage (Figure 5) [9, 18, 19]. In our series we have demonstrated good correlation between the imaging and arthroscopic findings. Discrepancies were seen in only three hips: underestimation of acetabular cartilage loss was seen in one hip, underestimation of femoral cartilage loss in another and an overestimation of acetabular cartilage loss was made in the last hip.

Femoroacetabular impingement is now well recognised as an important cause of hip pain and early-onset osteoarthritis. Femoral head and neck and acetabular morphological abnormalities in femoroacetabular impingement are well depicted by MDCT. An abnormal femoral head-neck junction osseous bulge was seen in 18 (19%) patients (Figure 6) and fibrocystic change at the head-neck junction in 8 (8%) patients (Figures 7 and 8) in

our series. Using MDCT arthrography we were also able to assess associated damage to the underlying labrum and cartilage, which is so often present in impingement. Furthermore, MDCT allowed assessment of the degree of acetabular version. The acetabulum is normally anteverted between 15 and 20 degrees. Acetabular version can be determined on anteroposterior radiographs of the pelvis with the pelvis in a neutral position. The anterior and posterior margins of the acetabulum should normally lie 1.5 cm apart and should meet at the superolateral margin of the acetabulum. If the acetabulum is retroverted, the lines will meet in the midportion of the acetabulum ("cross-over sign") and lie closer than 1.5 cm together [25]. The difficulty with this method lies in obtaining a radiograph with the pelvis in a truly neutral position, as alterations in pelvic tilt can lead to over- or underestimation of anteversion [26]. The



Figure 1. Axial CT demonstrates contrast extension (arrow) into an elongated anterior labrum in a patient with developmental dysplasia of the hip.

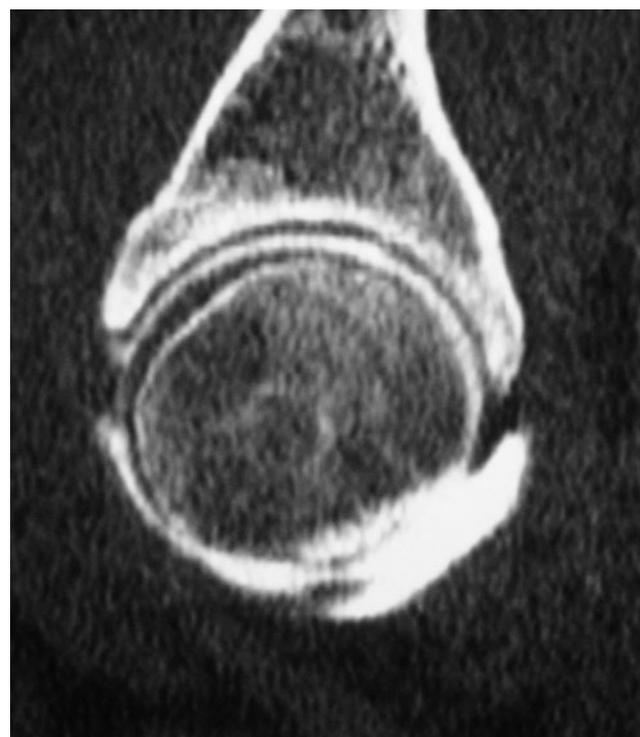


Figure 2. Sagittal reconstruction showing contrast extension through the labral base at the labral chondral transitional zone. Note how clearly the femoral and acetabular cartilage thickness is defined as being normal in this case.



Figure 3. Coronal reconstruction demonstrating a lateral paralabral cyst (arrowhead). There is also chondral loss with a discrete flap in the acetabular articular cartilage at the labral–chondral transitional zone (arrow).

radiographic studies give only an estimate of the degree of acetabular version, whereas CT allows for a more accurate assessment to be made. In our study we determined acetabular version by the method described by Tonnis et al [27]. A line is drawn connecting the anterior and posterior rims of the acetabulum; a second line, perpendicular to a line between the posterior pelvic margins, is then drawn. The angle between the intersection of these lines is the angle of acetabular version. Acetabular retroversion was seen in 11 (11%) patients in our study (Figure 9). This retroversion is associated with decreased clearance between the femur and acetabular rim during hip flexion, leading to pinching of the anterior labrum and increased incidence of tears and



Figure 4. Axial CT illustrates marked chondral loss in the posterior femoral head and adjacent acetabulum (arrow).



Figure 5. Sagittal reconstruction showing acetabular cartilage loss anteriorly (arrow) and a focal area of fibrocystic change in the anterior femoral head and neck junction (arrowhead). The anterior labrum demonstrates surface fraying and irregularity.

rim damage to the anterosuperior acetabular margin [28]. Of these patients with acetabular retroversion, five (45%) had labral tears, the majority of which were in the anterior labrum (see Table 2), and one patient had abnormality within the anterior labral–chondral transitional zone. Acetabular cartilage loss was also present in five patients, all in an anterior location. Associated pathology included one patient with a history of Perthe’s disease and two with a history of developmental hip dysplasia. Os acetabuli were seen in two patients. It was difficult to determine if these were true accessory ossicles or old rim fractures secondary to the abnormal acetabular version. Only 2 of the 11 patients had retroversion in both hips.

MDCT arthrography has further advantages beyond those of spatial resolution. Image acquisition is much



Figure 6. Coronal reconstruction shows abnormal osseous prominence at the femoral head and neck junction (arrowhead) in association with a lateral labral tear (arrow) in a patient with femoroacetabular impingement.



Figure 7. Coronal reconstruction showing an area of fibrocystic change at the femoral head and neck junction (arrow) in association with a lateral labral tear (arrowhead).

faster than for MRI, reducing any potential problems regarding patient movement. Furthermore, patients tolerate the examination well and claustrophobia is much less of an issue. Finally, if there are contraindications to MRI, or if the patient has had previous surgery with metal work *in situ*, then MDCT arthrography confers further advantages.

There are several limitations to our study. Firstly, a single musculoskeletal radiologist reported the studies; thus, intra- and interobserver variability could not be assessed. Secondly, the limited number of patients with operative correlation makes it difficult to draw conclusions on the sensitivity and specificity of MDCT arthrography in the hip. It is likely that a formal prospective trial with operative comparison would allow the relative strengths and weaknesses of this technique to be further evaluated. In this study we have termed the

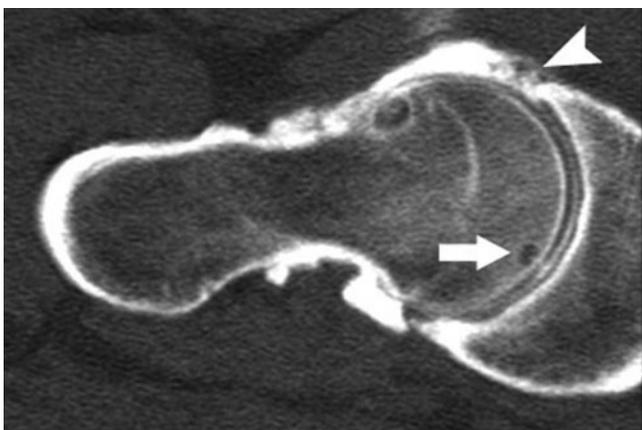


Figure 8. Axial oblique reconstruction in a patient with femoroacetabular impingement. An area of fibrocystic change is seen at the anterior femoral head and neck junction. There is a markedly irregular and torn anterior acetabular labrum (arrowhead). There is also a small subchondral cyst in the femoral head (arrow) and a tiny chondral cleft/fissure is seen superficial to this, extending from the surface of the articular cartilage to the subchondral bone.

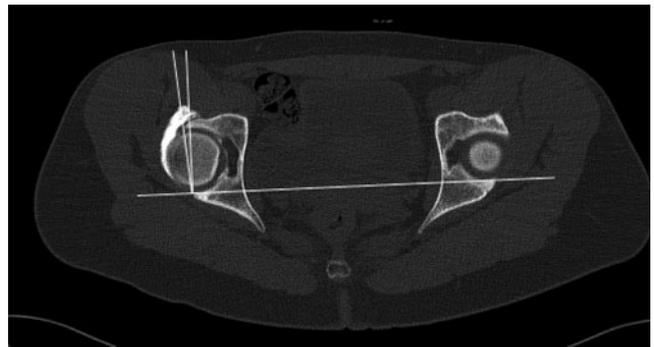


Figure 9. Axial CT image demonstrating acetabular retroversion. A line is drawn along the posterior margin of the acetabulum with a further line drawn perpendicular to this. A third line is then drawn between the anterior and posterior margins of the acetabulum, thus providing a measurement of the degree of acetabular version.

presence of lucency at the femoral head and neck junction as fibrocystic change. This definition is made on the basis of its typical appearance, location and morphology; however, pathological examination of these areas was not undertaken.

By performing MDCT arthrography rather than MRI, there is loss of the exquisite soft-tissue contrast that MRI affords. There is, therefore, the potential for unexpected findings within the soft tissues to be missed. To reduce this possibility, images were viewed on both soft tissue and bone algorithms; however, previous workers have demonstrated that when comparing CT and MRI in the detection of recurrent malignant disease, MRI is superior only for lesions less than 15 cm³ [29]. MR arthrography is usually performed with the use of a surface coil and a small field of view; thus, unexpected pelvic lesions might also be missed using this technique. Finally, CT imparts radiation on the pelvis, with the patient cohort included in this study being predominantly young patients. To minimise this radiation exposure, referral required assessment by a dedicated hip surgeon and abnormal findings were seen in 71% of cases.

We have demonstrated the wide range of abnormalities that can be identified by the use of MDCT hip arthrography. We believe that MDCT arthrography is a useful additional tool in the assessment of patients with suspected intra-articular hip pathology. This technology seems to have a similar sensitivity to MRI for the detection of labral pathology and superior ability to detect chondral loss. Finally, MDCT arthrography is likely to be of further use in patients for whom MRI is contraindicated or where previous surgery has been undertaken.

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