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Added value of interpreter experience in occult and suspect hip fractures: a retrospective analysis of 254 patients

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Abstract

Background: The influence of experience in categorizing suspect and occult fractures on radiography compared to MRI and clinical outcome has not been studied.

Purpose: To evaluate the importance of experience in diagnosing normal or suspect hip radiographs compared to MRI.

Methods: Primarily reported normal or suspect radiography in 254 patients with low-energy hip trauma and subsequent MRI was re-evaluated by two experienced reviewers. Primary readings and review were compared. The prevalence of fractures among normal and suspect radiographic studies was assessed. Clinical outcome was used as reference.

Results: At review of radiography 44 fractures (17%) were found. Significantly more fractures were found among suspect cases than among normal cases. At MRI, all 44 fractures were confirmed, and further 64 fractures were detected (25%). MRI detected all fractures with no missed fractures revealed at follow-up.

Conclusion: There was a significantly higher proportion of fractures at MRI among the suspect radiographic diagnoses for both the primary report and at review than among occult cases. The more experienced reviewers classified radiography examinations with higher accuracy than primary reporting general radiologists. There was almost complete agreement on MRI diagnoses.

Keywords

Proximal femur; hip; fracture; radiography; magnetic resonance imaging; occult

Introduction

Hip fracture after low-energy trauma in the elderly is a worldwide problem and an increasing global health care challenge. In an aging population the incidence of hip fractures increases exponentially with age, with an estimated annual incidence of 6.3 million world-wide in 2050 [1, 2]. Most hip fractures can be diagnosed straightforwardly with radiography [3] but non-displaced fractures may be radiographically suspect or occult, necessitating further investigation with modalities such as computed tomography (CT) [4] or magnetic resonance imaging (MRI) [5].

Belated recognition of a hip fracture can result in increased morbidity with extended hospitalization and a substantial decrease in quality of life [6, 7]. A delay in operative treatment has a strong correlation with increased mortality [8, 9]. These serious consequences necessitate prompt and correct diagnosis for immediate treatment planning or discharge.

Approximately one to four percent of all hip fractures are missed at radiography [10-12] and need a second-line investigation. All referrals for hip fracture in metropolitan Gothenburg are handled at the Sahlgrenska University Hospital/Mölndal where yearly about 1000 operations for acute hip fractures are performed. The statistics based on examination codes do not differentiate between acute and selective hip radiographies. A rough estimate is that about every third examination is for acute hip trauma. A small percentage of these examinations need further investigation. In numbers the patient cohort is small. However, reaching a fast and accurate diagnosis is not only a cost-saving measure and an intellectual challenge, but to a high degree an ethical and moral obligation.

A reason to differentiate between occult and suspect fractures is that for negative radiography the radiologist is no longer required to recommend additional imaging, but in case of a suspect fracture additional imaging is necessary for clarification. A truly occult fracture is usually defined as clinical symptoms or signs of fracture without any radiographic evidence [3]. A suspect fracture may show subtle radiographic signs that are not enough for definite diagnosis but still cannot be characterized as quite normal. Perusal of the literature shows no study with clear or at least clearly apparent distinction between occult and suspect hip fractures which may be one reason for reported frequency variations. The published studies are too heterogeneous to allow any sensible meta-analyses.

There are no clinical decision rules for exclusion of hip fracture without imaging [3], which necessitates that patients with negative or suspect radiographs and a remaining clinical suspicion of hip fracture be submitted to second-line investigation for final diagnosis. Several national guidelines recommend MRI as first choice second-line survey when additional imaging is needed [3, 13, 14].

The purpose of the current study was to evaluate the possible value of interpretation experience in assessing radiographic occult and suspect hip fracture compared to MRI.

Material and Methods

Consecutive imaging data for all radiographic and MRI examinations with primarily reported negative or suspect hip radiography during eight years (2006-2013) were retrospectively retrieved from the radiology information system (RIS) and picture archiving and communication system (PACS). The MRI codes were pelvis, hip, or femur. Control of referral diagnoses was made both in the hospital information system (HIS) and the RIS.

Totally 308 patients with low-energy trauma and normal or suspect hip radiography and remaining clinical symptoms suggestive of hip fracture were referred to MRI. Excluded were 54 patients referred to MRI without a clear hip trauma or for evaluation of the extension of a known hip fracture. Thus, the study population comprised 254 patients, 83 men, mean age 78 years (range 53 – 97) and 171 women, mean age 82 years (range 50 – 107). Only hip fractures were evaluated. Co-existing or pelvic fractures alone or soft tissue lesions were not recorded. All MRI examinations were performed during office hours on week-days. About half of the patients (56%) were examined immediately or within 24 hours. Mean time between radiography and MRI was 2.5 days (range 0 – 7 days). In 32 cases the MRI examination was delayed as an inconclusive CT was performed or in a few cases MRI was not available within 48 hours. There was no interim trauma between the examinations.

All digital radiography was performed with standard imaging protocols, including an AP pelvis and an AP and a cross-table lateral hip radiograph. MRI was performed on a 1.5 T whole-body Somatom Sensation scanner (Siemens, Erlangen, Germany). The scan protocol 2006 to 2009 consisted of a 5 mm slice thickness coronal turbo spin-echo (SE) T1-weighted sequence (TR=470, TE=12) and a short-tau inversion recovery (STIR) sequence (TR=5060, TE=104) or a coronal fat-suppressed fast SE T2-weighted sequence (TR=4710, TE=86). From

2010 the protocol changed to a 3.5 mm slice thickness coronal turbo SE T1-weighted sequence (TR=518, TE=14) and a 4 mm slice coronal STIR sequence (TR=4760, TE=67).

All 254 primarily reported radiography and MRI examinations were read by general radiologists. At review, all imaging studies were read independently and blinded from each other and to clinical follow-up, but no to age and sex by two observers with long experience in musculoskeletal radiology and special interest in hip fracture diagnosis. When there was disagreement on diagnosis possible reasons for discrepancies were discussed and in all cases a consensus diagnosis was reached. The primary radiographic reports were divided into the groups no fracture, suspect fracture, or definite fracture. At review both radiography and MRI findings were scored as negative, suspect or definite for fracture.

The clinical outcome regarding surgical or conservative treatment was retrieved from the HIS. Also, follow-up for all patients regarding any adverse events such as treatment complications or re-admissions of conservatively managed patients for displacement of fracture were retrieved from the HIS. Minimum two months follow-up was available for all but two patients who died prior to surgery.

A suspect fracture at radiography was defined as inconclusive cortical and/or trabecular disruptions. Fractures at MRI were defined as linear low signal on T1-weighted sequences bordered by high signal intensity areas on STIR or fat saturated T2-weighted sequences. *Statistics*: Cohen’s kappa with linear weighting and 95% confidence interval was used to evaluate observer agreement between the primary reports and review in terms of relative concordance. Since suspect diagnoses were given less statistical weight than definite or no fractures in case of observer disagreement, linear weighting was applied. Kappa (k) values <0 represent less than mean-chance agreement, 0.01-0.20 slight agreement, 0.21-0.40 fair agreement, 0.41-0.60 moderate agreement, 0.61-0.80 substantial agreement, 0.81-0.99 almost perfect agreement, and 1 perfect agreement [15]. A chi-square analysis was performed to analyse differences between the numbers of reported suspect and definite fractures at primary radiographic reporting and review, and differences between fractures detected by MRI among occult and suspect fractures.

Results

Primary radiography compared with radiography review

At review there was agreement with primary reporting on 143 of 168 (85%) negative diagnoses and on 32 of 86 (37%) suspect fractures (Table 1). At review significantly more fractures were detected by the experienced reviewers than at primary reading. The reviewers scored 20 definite fractures primarily reported as negative and 24 definite fractures primarily reported as suspect. Thus, treatment delayed by subsequent MRI could have been avoided in 44 definite fractures (17%). The difference was statistically significant difference ($P<0.0001$).

Primary radiography compared with primary MRI

MRI changed the radiographic diagnoses in 148 cases (58%). A total of 108 fractures (43%) were found at MRI (Table 2). In 86 suspect radiographic studies MRI detected 46 fractures (54%). In 168 radiographically normal cases MRI detected 62 occult fractures (37%).

Primary MRI compared with MRI review

There were no suspect fractures at MRI. Disagreement on fracture location between the primary report and review arose in only two cases (0.8%); one trochanteric fracture was primarily diagnosed as cervical and uneventfully operated on with parallel nails and a complete cervical fracture was primarily reported as trochanteric due to a short vertical intertrochanteric extension without cortical disruptions within the trochanteric region.

Review of radiography compared with MRI review

At MRI, all 44 definite fractures scored at review of radiography were verified, thus there were no false positive fractures. Among the remaining 210 studies with negative or suspect radiographic findings, a total of 63 fractures (30%) were detected (Table 3); 27 definite fractures were scored among the 37 suspect fractures (73%) and 36 occult fractures were found among the 173 normal cases, i.e. false negative diagnoses (21%). Significantly more fractures were detected among radiographically suspect cases (Fig 1) than among radiographically normal cases ($P<0.0001$).

MRI compared with clinical outcome

There were 50 cervical fractures at MRI of which 38 were operated on with parallel nails. Six patients were treated with dynamic hip screws (DHS). One patient received total hip replacement due to co-existing severe hip osteoarthritis. Three patients were conservatively treated for non-surgical reasons and two died before surgery. Of 58 patients with trochanteric fractures, 48 were operated on with DHS, one patient was treated with total hip replacement due to hip osteoarthritis and nine patients with incomplete trochanteric fractures were treated conservatively (Table 4). All patients with negative MRI as well as all conservatively managed patients had an uneventful clinical course during which no missed fractures were revealed.

Observer agreement

The agreement for radiography between primary reporting and review was “fair” with linear weighted kappa (k) 0.31 (SE; 0.04, 95% CI; 0.23-0.38). The agreement for MRI between the primary reports and review was “almost perfect” (unweighted kappa 0.99, SE; 0.01, 95% CI; 0.97-1.0).

Discussion

Perusal of the literature shows no patent distinction between occult fractures with initially negative radiographs from suspect radiographs and several reported series confuse these entities [16-19]. The prevalence of occult hip fracture varies widely in the literature with an estimated sensitivity of hip radiography between 91 – 98% [3, 12]. In a study on 1108 patients, Pathak et al [10] reported a prevalence of 0.7% occult hip fractures, reporting all their false negative cases as invisible on the initial radiographs. Fairclough et al [20] reported an incidence of 1.9% occult fractures with negative radiographs in a study on 663 patients. Occult fracture rates of 2 - 5% have been reported [3, 12, 21, 22]. The prevalence of occult and suspect hip fractures at our clinic cannot be presented as the radiographies are equally coded for acute and selective examinations and both CT and MRI are used as second-line investigation after hip trauma. The prevalence is, however, low.

In the current study where experienced review of radiography in occult and suspect hip fracture was compared with the original reports more than twice as many suspect diagnoses were given in the primary radiographic reports compared with in the review. There were almost twice as many false negative cases for the primary report (37%) compared to after review (21%), i.e. a higher proportion of negative fractures were primarily reported than were found after review. Contrarily, there was a higher proportion of fractures at MRI in the group suspect fractures after review (73%) than at primary reporting (53%). In total, MRI detected a higher rate of missed fractures at primary reporting than after review of the radiographs. Thus, after review, a number of equivocal cases could be scored as normal or as a definite fracture on radiography obviating the need for further imaging and thus allowing immediate treatment planning or discharge. Some normal cases could be scored as a definite fracture. In total, MRI detected a higher rate of missed fractures at primary reporting than after review of the radiographs.

The interobserver agreement between the primary report and review in the current study is somewhat lower than previously reported [23], where the scoring of different observers and modalities was evaluated under identical conditions. In the current study this was not the case, where primary reports from the clinical situation were compared with image review in a study situation. The interobserver agreement for MRI was almost perfect (k=0.99) which shows a high diagnostic reproducibility and is in line with previously reported data [23]. Also, the accuracy for MRI in diagnosing occult and suspect hip fractures is well documented in the literature with figures reported as about 93-100% [3, 19, 24, 25]. In the current study the clinical follow-up revealed no missed fractures at MRI.

To our knowledge there are no previous reports on the benefit of MRI in cases with a clear distinction between occult and suspect radiographs. In radiographic diagnosis, an occult or "hidden" hip fracture is one in which the clinical findings are suggestive of a fracture but this is not confirmed by radiographs [5, 18, 26].

The current study is retrospective. It would, however, probably be impossible to collect such a large study cohort on suspect occult hip fractures prospectively. The study presents data from a single institution and may not be fully applicable to other institutions.

In conclusion, this study shows a significantly higher proportion of fractures at MRI among the suspect radiographic diagnoses for both the primary report and at review than among occult cases. This indicates that where subtle fracture signs raise suspicions of fracture, an experienced radiologist may diagnose a definite fracture. There was complete agreement on

MRI diagnoses in all but two cases which demonstrates that there are few problems in interpreting MRI.

Compliance with ethical standards

The study was approved by the Regional Board of Ethics

Conflict of interest

The authors declare that they have no conflict of interest

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Tables and figure legends

Table 1. Comparison of primary reporting and review for radiography in 254 patients. There was agreement on 143 negative and 32 suspect cases. Another two suspect fractures were reported in different locations by the reviewers. There were more than twice as many suspect fractures in the primary report. The reviewers scored 44 definite fractures.

Table 2. Primary reports of 254 radiographically negative or suspect fractures and subsequent MRI. MRI changed the radiographic diagnoses in 148 cases (58%) of which 62 were false negative. [1]There were four times as many suspect cervical (n=69) than suspect trochanteric (n=17) fractures. Forty-one suspect fractures were confirmed (30 cervical; 11 trochanteric) and five suspect cervical were changed to trochanteric fractures after MRI.

Table 3. Review of 254 primarily reported radiographically negative and suspect fractures with subsequent MRI. MRI changed the radiographic diagnoses in 73 cases (29%). There were 36 false negative diagnoses. [1]There were four times as many suspect cervical (n=30) than suspect trochanteric (n=7) fractures. Twenty-seven suspect (23 cervical; 4 trochanteric) and all 44 definite fractures were confirmed.

Table 4. Clinical outcome compared to MRI for primary reports and review in 254 patients. One cervical fracture was diagnosed as trochanteric at review and vice versa ([1]). There were no suspect fractures at MRI. All patients with negative diagnoses were treated conservatively. Five cervical fractures received conservative treatment for non-surgical reasons. Decisions to operate six cervical fractures with DHS were made by the orthopedic surgeon on call due to signal changes in trabecular bone within the basicervical region. Nine trochanteric fractures were incomplete (no disruption of the medial cortex) and conservatively treated.

Caption figure

Male, 90 years. Radiography (a) was interpreted as no signs of fracture in the primary report while a suspect fracture with subtle signs of impacted trabeculae was diagnosed at review (white arrow). The lateral femoral neck was interposed by the tip of the greater trochanter making the diagnosis of cortical disruption in this region difficult. Subsequent MRI shows a complete fracture line (b) through the femoral neck (T1-sequence, black arrows) with a corresponding edema (grey arrow) at STIR-sequence (c)

Table 1. Comparison of primary reporting and review for radiography in 254 patients

Primary reports	Review			
	Negative	Suspect	Definite	Total
Negative	143	5	20	168
Suspect	30	32	24	86
Total	173	37	44	254

There was agreement on 143 negative and 32 suspect cases. Another two suspect fractures were reported in different locations by the reviewers. There were more than twice as many suspect fractures in the primary report. The reviewers scored 44 definite fractures.

Table 2. Primary reports of 254 radiographically negative or suspect fractures and subsequent MRI

Radiography	MRI			
	Negative	Suspect	Definite	Total
Negative	106	0	62	168
Suspect[a]	40	0	46	86
Total	146	0	108	254

MRI changed the radiographic diagnoses in 148 cases (58%) of which 62 were false negative.
[a]There were four times as many suspect cervical (n=69) than suspect trochanteric fractures (n=17). Forty-one suspect fractures were confirmed (30 cervical; 11 trochanteric) and five suspect cervical were changed to trochanteric fractures after MRI.

Table 3. Review of 254 primarily reported radiographically negative and suspect fractures with subsequent MRI

Radiography	MRI			
	Negative	Suspect	Definite	Total
Negative	137	0	36	173
Suspect[a]	10	0	27	37
Definite	0	0	44	44
Total	147	0	107	254

MRI changed the radiographic diagnoses in 63 cases (30%). There were 36 false negative diagnoses.

[a]There were four times as many suspect cervical (n=30) than suspect trochanteric (n=7) fractures. Twenty-seven suspect (23 cervical; 4 trochanteric) and all 44 definite fractures were confirmed.

Table 4. Clinical outcome compared to MRI for primary reports and review in 254 patients

MRI	Primary report / Review	Outcome			
		Conservative treatment	Parallel nails	Dynamic hip screw	Hip replacement
Negative	146	146	0	0	0
Cervical	50[1]	5	38	6	1
Trochanteric	58[1]	9	0	48	1
Total	254	160	38	54	2

One cervical fracture was diagnosed as trochanteric at review and vice versa ([1]). There were no suspect fractures at MRI. All patients with negative diagnoses were treated conservatively. Five cervical fractures received conservative treatment for non-surgical reasons. Decisions to operate six cervical fractures with DHS were made by the orthopedic surgeon on call due to signal changes in trabecular bone within the basicervical region. Nine trochanteric fractures were incomplete (no disruption of the medial cortex) and conservatively treated.

Fig 1 Male, 90 years. Radiography (**a**) was interpreted as no signs of fracture in the primary report while a suspect fracture with subtle signs of impacted trabeculae was diagnosed at review (*white arrow*). The lateral femoral neck was interposed by the tip of the greater trochanter making the diagnosis of cortical disruption in this region difficult. Subsequent MRI shows a complete fracture line (**b**) through the femoral neck (T1-sequence, *black arrows*) with a corresponding edema (*grey arrow*) at STIR-sequence (**c**).