Hip MRI findings and outcomes following imaging-guided hip injections

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Abstract: OBJECTIVE To determine if MRI findings prior to intra-articular corticosteroid hip infiltration are related to treatment outcomes. METHODS This prospective outcome study with retrospective MRI evaluation includes 100 consecutive patients with MRI within 6 months before a therapeutic intra-articular hip injection. Labrum, bone marrow, acetabular and femoral cartilage abnormalities were assessed by two radiologists blinded to patient outcomes: the proportion reporting "improvement" on the Patient's Global Impression of Change (PGIC) scale at 1 day, 1 week and 1 month follow-up were compared based on MRI findings using ^{2}. The t-test was used to compare pain change scores with MRI abnormalities. RESULTS Patients with a normal labrum in the posterosuperior quadrant were more likely to report PGIC "improvement" at 1 week compared to labral degeneration (p = 0.048). Significant differences in pain change scores were found at all time points for the labral anteroinferior quadrant (p = 0.001, 1 day; p = 0.010, 1 week; p = 0.034, 1 month) with the highest reduction in patients with labral degeneration. Females were 2.80 times more likely to report clinically relevant "improvement" at 1 day (p = .049) and 2.90 times more likely to report clinically relevant "improvement" at 1 month (p = .045). CONCLUSION Cartilage defects and marrow abnormalities were not associated with outcomes. Patients with a normal labrum in the posterosuperior quadrant had better outcomes at 1 week. Patients with labral degeneration of the anteroinferior quadrant had higher levels of pain reduction at all time points. Females were significantly more likely to report PGIC "improvement". ADVANCES IN KNOWLEDGE A significant treatment outcome was observed amongst gender, although there were no significant differences in the MRI findings.

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FULL PAPER

Hip MRI findings and outcomes following imaging-guided hip injections

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Objective: To determine if MRI findings prior to intra-articular corticosteroid hip infiltration are related to treatment outcomes.
Methods: This prospective outcome study with retrospective MRI evaluation includes 100 consecutive patients with MRI within 6 months before a therapeutic intra-articular hip injection. Labrum, bone marrow, acetabular and femoral cartilage abnormalities were assessed by two radiologists blinded to patient outcomes: the proportion reporting "improvement" on the Patient's Global Impression of Change (PGIC) scale at 1day, 1week and 1month follow-up were compared based on MRI findings using χ^2. The *t*-test was used to compare pain change scores with MRI abnormalities.
Results: Patients with a normal labrum in the posterosuperior quadrant were more likely to report PGIC "improvement" at 1week compared to labral degeneration (p = 0.048). Significant differences in pain change scores were found at all time points for the labral anteroinferior quadrant (p = 0.001, 1day; p = 0.010, 1week; p = 0.034, 1month) with the highest reduction in patients with labral degeneration. Females were 2.80 times more likely to report clinically relevant "improvement" at 1day (p = .049) and 2.90 times more likely to report clinically relevant "improvement" at 1month (p = .045).
Conclusion: Cartilage defects and marrow abnormalities were not associated with outcomes. Patients with a normal labrum in the posterosuperior quadrant had better outcomes at 1week. Patients with labral degeneration of the anteroinferior quadrant had higher levels of pain reduction at all time points. Females were significantly more likely to report PGIC "improvement"
Advances in knowledge: A significant treatment outcome was observed amongst gender, although there were no significant differences in the MRI findings.

INTRODUCTION

Intra-articular corticosteroid injections are widely used for the treatment of knee and hip osteoarthritis (OA).[1,2] Studies have shown that corticosteroid injections into the hip articulation in OA patients are related to short-term pain reduction, irrespective of the arthritis severity.[1,2] Several authors have compared the effects of intra-articular corticosteroid injections with injections of either hyaluronic acid, analgesics or placebo on patients with hip OA, showing significantly better efficacy of corticosteroid compared to placebo or analgesic injections.[3–5]

A variety of possible anatomical correlates have been reported in patients with hip pain. Hip OA patients often have labral tears. However, labral defects are often asymptomatic and common in most patients above age 70.[6] A retrospective study on hip arthroscopy patients observed greater pain relief in patients with both labral and chondral defects than in patients without cartilage pathology.[6] It has been proposed that a possible source of pain caused by hip OA could be the stimulation/irritation of pain fibers in the cartilage.[7] The development of bone marrow edema following cartilage defects has been described by numerous studies for the knee joint,[8–10] and also occurs in hip OA.[8]

Several studies have sought to identify predictors of a good response to intra-articular corticosteroid injections. In their study on knee OA patients, Jones et al[11] could not determine clinical predictors for a positive response. Plant et al[12] observed a short-term improvement of the pain in both OA and rheumatoid arthritis of the hip, but independently of their radiographic characteristics/severity. To

our knowledge, no data have been published on the relationship of MRI-findings before an intra-articular infiltration of the hip joint and patient treatment outcomes.

Therefore, the purpose of this study was to assess whether the abnormal findings seen on MRI prior to injection are related to the outcomes of imaging-guided therapeutic hip injections over 1 month.

METHODS AND MATERIALS

Study design and patient population

This hip cohort outcome study was conducted at a specialized Orthopaedic University Hospital. A total of 100 consecutive patients referred to the radiology department who met the inclusion criteria, received an imaging-guided therapeutic hip injection, provided baseline pain level data and answered two outcome measures at 1 day, 1 week and 1 month follow-up (FU) were included. These patients were part of the large database of therapeutic injections outcomes collected prospectively by the radiology department between November 2009 and September 2015 and were all treated for primary OA. No other additional treatments than the intra-articular injection were offered. Patients had to meet the following inclusion criteria: (a) be at least 40 years old; (b) have an intra-articular injection of one hip; (c) had a non-contrast MRI or MR arthrography of the relevant hip acquired no longer than 6 months prior to injection; (d) be able to read and understand the questionnaires (in German); (e) answer all baseline and FU questionnaires. Exclusion criteria were: (a) diagnostic imaging evidence of femoroacetabular impingement (a consensus reading by two musculoskeletal radiologists), (b) hip-prosthesis or previous surgery of the hip joint, (c) extra-articular injections (trochanteric bursa or iliopsoas tendon). Ethics approval was obtained from the hospital and county ethics committees (EK 12/2009). Informed consent was obtained before the injection.

MRI protocols

The conventional MRI scans as well as the MR arthrograms were done using a 1.5 T system (Avanto or Espree, Siemens Healthcare, Erlangen, Germany) using a flexible four-channel body matrix phased-array surface coil and a six-channel spine matrix coil integrated into the examination table and included a single hip. As a standard, secondary radial reformations are performed in all patients, based on the three-dimensional transverse oblique water-excitation true fast imaging with steady-state precession (FISP) sequence. Details of the specific sequences are shown in Table 1.

Data collection and imaging reading

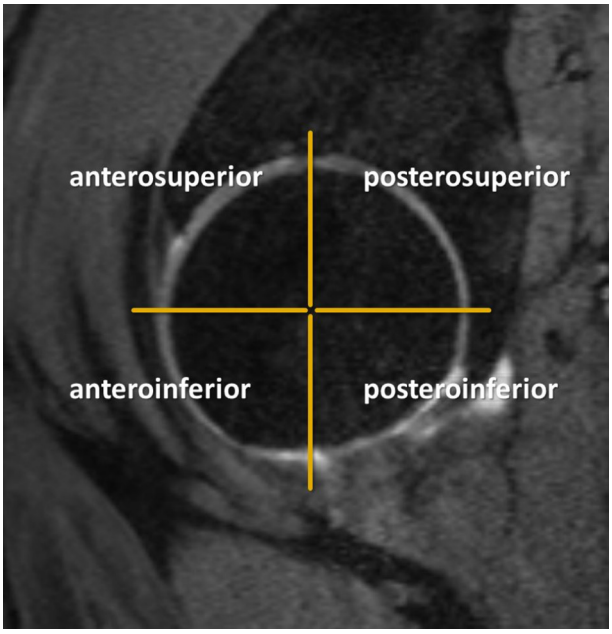
The MRI examinations acquired prior to the injection were read retrospectively in consensus and blinded to the treatment outcomes by two musculoskeletal radiologists having respectively 12 and 14 years of expertise in this field. Included were unilateral MRI examinations without (non-contrast MRI) (N = 33) or with (MR arthrography) intra-articular contrast agent of the hip joint (N = 67), which were performed within 6 months prior to the therapeutic injection. Three groups of anatomical structures (labrum, bone marrow and cartilage) were evaluated. The hip articulation was anatomically divided into four quadrants (anterosuperior, anteroinferior, posterosuperior and posteroinferior) (Figure 1).[13] For each quadrant, the following subclassification of findings was performed: for the labrum, the presence of (1) labral degeneration, (2) labral tear (Figure 2), or (3) the combination of labral degeneration and tear was recorded. For bone marrow abnormalities, the presence of (1) bone marrow edema, (2) a subchondral cyst (Figure 3) or (3)

Table 1. Parameters for unilateral hip examination at 1.5 T MRI

	Coronal T_1 weighted spin-echo sequence	Coronal intermediate-weighted fast spine-echo with fat saturation sequence	Sagittal water-excitation 3D double-echo steady-state sequence	Sagittal T_1 weighted spine-echo sequence	3D transverse oblique (parallel to long axis of femoral neck) water-excitation true fast imaging with steady-state precession (FISP) sequence
TR/TE	527/14	3520/39	25.2/8.6	550/13	11.7/5.2
Flip angle	150°	150°	25°	180°	28°
Section thickness	3 mm	3 mm	1.7 mm	4 mm	1.25 mm
Intersection gap	0.6 mm	0.6 mm	None	0.8 mm	None
FOV	18 cm	18 cm	16 cm	18 cm	17 cm
Matrix	384 × 269	320 × 320	384 × 256	320 × 256	384 × 256
Turbo factor	2	-	-	2	-
Number of signals acquired	2	1	1	2	2

3D, three-dimensional; FOV, field of view; TR/TE, repetition time/echo time; cm, centimeters; mm, millimeters.

Figure 1. Sagittal MRI slice showing the four quadrants of the hip for analysis.



both bone marrow edema and a subchondral cyst was recorded. The acetabular and femoral cartilages were assessed separately, and pathological findings were graded by the presence of damage leading to (1) ≤50% thickness or (2) >50% thickness substance defect of the cartilage (Figure 4). Finally, for all three structures, absence of the designated abnormal finding gave the grade of 0.

Imaging-guided therapeutic injection protocol

The therapeutic injections were performed at this hospital by experienced radiologists under sterile conditions (three times disinfection of the skin, sterile gloves, mask and drapes). First, an injection of contrast agent (2 ml Iopamidol (IOPAMIRO 200 mg ml^{-1}; Bracco Suisse SA, Manno, Switzerland)) was performed in the hip joint under fluoroscopic guidance in order to control the positioning of the 21G-needle. Then the patient received an injection of a local anesthetic (5 ml of 2% Lidocain

Figure 2. Transverse T_2W MR arthrogram in a 44-year-old female showing a posterior labral tear in the hip joint. T_2W, T_2 weighted.

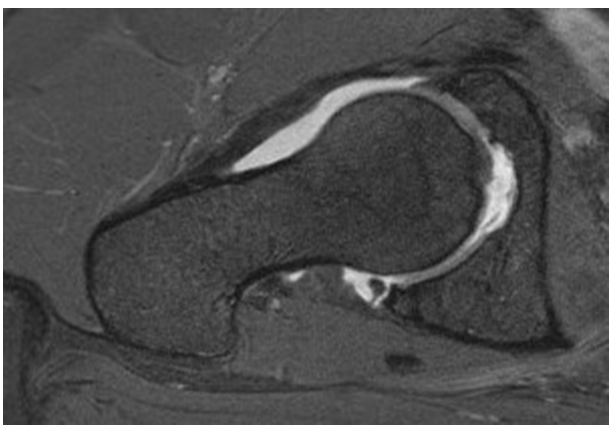
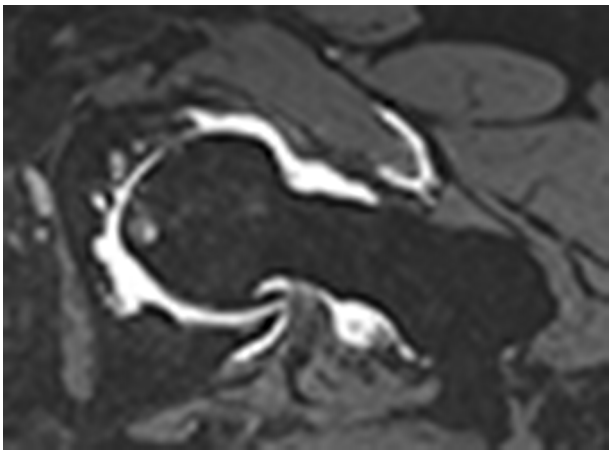


Figure 3. Transverse T_2W MR arthrogram in a 70-year-old female showing acetabular and femoral cysts in the hip joint, severe cartilage loss and subtle bone marrow edema pattern.T_2W, T_2 weighted.



hydrochloride (RAPIDOCAIN 2%; Sintetica SA, Mendrisio, Switzerland)), followed by 1 ml of corticosteroid (1 ml Triamcinolone acetonide (TRIAMCORT 40 mg ml^{-1}; Helvepharm AG, Frauenfeld, Switzerland)) (Figure 5). All patients received injections containing only corticosteroid and anesthetic.

Assessment of patient outcomes

The assessment of over all treatment outcome, collected prospectively, was performed using the Patient's Global Impression of Change for overall improvement (PGIC) (primary outcome measure) and the Numerical Rating Scale for pain (NRS) (Figure 6), which have been established since 2009 as in-house questionnaires to collect the outcomes for imaging-guided

Figure 4. Sagittal T_2W MR arthrogram in a 43-year-old female showing acetabular cartilage delamination in the hip joint as well as multiple subchondral cysts and full thickness cartilage loss. T_2W, T_2 weighted.

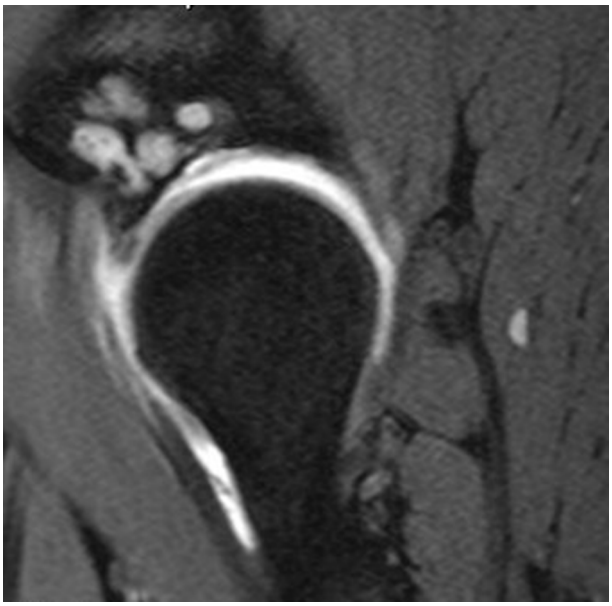


Figure 5. Intra-articular hip infiltration under fluoroscopic guidance.

therapeutic injections and were described in previous studies as "the most valid, reliable, and time-effective outcome measures."[14,15]

The PGIC is a 7-point scale including the responses "much better," "better," "slightly better," "unchanged," "slightly worse," "worse" and "much worse." This scale includes the subjective improvement in terms of activity limitations, symptoms, emotions and overall quality of life. The PGIC scale was the primary outcome measure and was dichotomized into "improved" or "not improved" and "worse" or "not worse." The responses "much better" and "better" were considered clinically relevant "improvement" consistent with other studies.[14–17] All other responses were considered "not improved." The responses "slightly worse," "worse," and "much worse" were all considered worsening of the condition and dichotomized as "worse." All other responses were "not worse."[14–17] The responses "slightly better" and "unchanged" were categorized as "unchanged.

The NRS is graded from 0 (=no pain) to 10 (=unbearable pain), where the patient is asked to rate the actual pain in the infiltrated joint at the time of the specific data collection. Patients were required to complete the NRS before the injection while in the radiology department (baseline) and both NRS and PGIC were recorded at 1 day, 1 week and 1 month after injection. The FU NRS and PGIC questionnaires were handed to the patients directly after the injection along with a postage pre-paid envelope. Patients were instructed to return the completed questionnaires after the last data collection time point of 1 month.

Statistical analysis

Descriptive statistics were calculated for age and gender of the study population and the percentage of pathological MRI findings by each quadrant of the labrum, the bone marrow or the articular cartilage. The proportion of patients reporting clinically relevant "improvement" (primary outcome) was calculated for each of the data collection time points and compared with the various MRI abnormalities using the χ^2 test. The same analysis was done for the proportion of patients reporting worsening of their condition. Gender differences for improvement and worsening were also assessed using the χ^2 test. ANOVA test and Student's *t*-tests were used to compare the NRS change scores with imaging findings. Logistic regression was performed to assess the impact of patient sex, age and baseline pain scores on "improvement" at each data collection time point. The χ^2 test was also used to compare the proportion of patients "improved" or "worse" between the patients having routine MRI *vs* MR arthrograms for each data collection time point.

The statistical analyzes were done using the SPSS statistics program (v. 21, IBM, Armonk, NY).

RESULTS

From the original sample of 114 patients, a total of 100 patients (33 males and 67 females) met the inclusion criteria. Of these, 67

Figure 6. The two outcome measures used for this study: The NRS and the PGIC. NRS, Numerical Rating Scale; PGIC, Patient's Global Impression of Change.

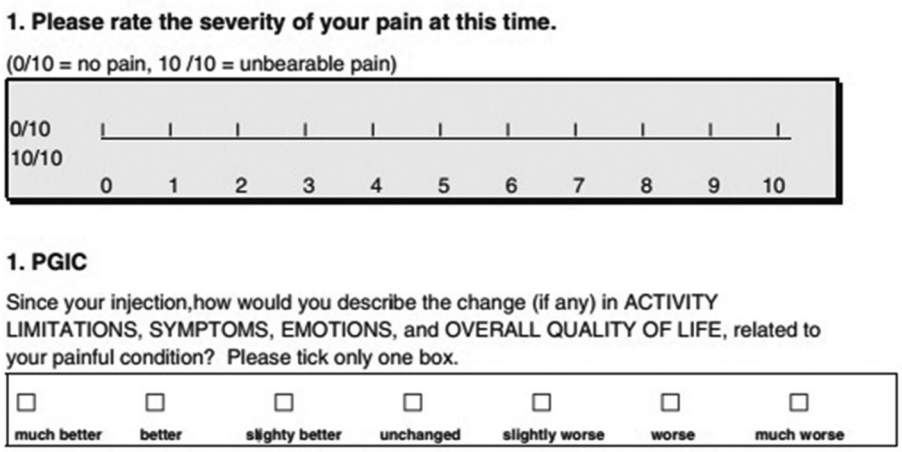


Table 2. Percentage of patients with the various MRI findings by quadrant in a defined anatomical region (% within quadrant of the anatomical region)

MR finding by anatomical region	Localization in quadrant			
	Anteroinferior	Anterosuperior	Posterosuperior	Posteroinferior
Labrum				
No tear	38%	4%	34%	75%
Degeneration	27%	19%	46%	20%
Tear	11%	14%	4%	1%
Degeneration + tear	24%	63%	16%	4%
Acetabular bone marrow				
No bone marrow edema	90%	78%	90%	95%
Bone marrow edema	2%	2%	3%	0%
Subchondral cyst	6%	11%	4%	5%
Edema + Subchondral cyst	2%	9%	3%	0%
Femoral bone marrow				
No bone marrow edema	96%	87%	86%	95%
Bone marrow edema	2%	4%	7%	4%
Subchondral cyst	2%	5%	3%	1%
Edema + Subchondral cyst	0%	4%	4%	0%
Acetabular articular cartilage				
No damage	87%	59%	76%	82%
Damage with ≤50% substance defect of thickness	7%	20%	13%	13%
Damage with >50% substance defect of thickness	6%	21%	11%	5%
Femoral articular cartilage				
No damage	88%	70%	78%	82%
Damage with ≤50% substance defect of thickness	7%	16%	12%	11%
Damage with >50% substance defect of thickness	5%	14%	10%	7%

patients had MR arthrography and 33 had MR without contrast. The mean (±SD) age of the cohort was 52.2 (±10.52) years and there was no significant age difference between the genders (p = 0.91).

The baseline mean NRS score (±SD) for all patients was 5.81 (±2.1), and the 15 min mean NRS score was 3.51 (±2.60) with no significant gender differences (p = 0.93). There were also no gender differences for the NRS scores at all FU time points ($p \geq$ 0.38).

The proportion of patients with the various MRI abnormalities by quadrant is shown in Table 2. Articular cartilage and labral abnormalities were most common in the anterosuperior quadrant, with 63% of patients having both labral degeneration and a tear in this region. 41% of patients had articular cartilage lesions in the anterosuperior quadrant on the acetabular side of the joint (21% with greater than 50% thickness) and 30% had damage in the anterosuperior quadrant on the femoral side of the joint (14% with greater than 50% thickness). The vast majority of patients had no bone marrow edema or subchondral cyst, either in the acetabulum or the femoral head.

Table 3 shows the proportion of patients "improved" or "worse" at each of the two data collection time points. There was no significant age difference in the proportion of patients "improved" or "worse" for any of the data collection time points (p > 0.15). However, there was a significant gender difference in the proportion of patients "worse" at 1 month. For male patients 31.3% (n = 10/32) reported being "worse" compared to 8.9% (n = 6/67) of the female patients (p = 0.012). Because males had a significantly higher proportion of patients reporting "worsening" at the 1 month time point, post-hoc analysis compared sex of the patients with the various MRI abnormalities using the χ^2 test.

Table 3. Percentage of patients reporting improvement/worsening at each follow-up time point (PGIC, primary outcome)

	Improved	Worse	Unchanged
At 1 day follow-up	31.3%	13.1%	55.6%
At 1 week follow-up	43.4%	8.1%	48.5%
At 1 month follow-up	32.3%	16.2%	51.5%

PGIC, Patient's Global Impression of Change.

There was no significant association for any of the abnormalities based on sex. Additionally, logistic regression analysis found that females were 2.80 times more likely to report clinically relevant "improvement" at 1 day (p = .049) and 2.90 times more likely to report clinically relevant "improvement" at 1 month (p = .045) compared to males. The baseline NRS scores and patient age were not related to "improvement" using logistic regression.

Articular cartilage defects and bone marrow abnormalities at MRI were not related to overall "improvement." Specifically, there was no significant relationship between the proportion of patients reporting "improvement" (p ranged from 0.26 to 0.93) or "worsening" at 1 day (p ranged from 0.06 to 0.73) or 1 month (p ranged from 0.13 to 0.94 for improvement and 0.07–0.79 for worsening) and any of the specific MRI findings in any of the anatomical quadrants. However, at 1 week there was a statistically significant difference in the proportion of patients reporting "improvement" depending on the presence or absence of labral pathologies in the posterosuperior quadrant (p = 0.048). Post-hoc analyzes for this anatomical region and time point revealed that 55.9% of the patients in the "normal labrum"-category improved, 46.7% in the "labral degeneration and tear"-category and 37.0% in the "labral degeneration alone"-category.

Comparing the NRS change scores for each of the MRI abnormalities by quadrant found statistically significant differences at all-time points only for labral findings in the anteroinferior quadrant (p = 0.0001 at 1 day, 0.007 at 1 week, 0.029 at 1 month). Post-hoc unpaired t-tests were then conducted to determine which specific labral findings had greater and lesser pain relief, showing that patients in the "labral degeneration"-category had the highest NRS change scores (*i.e.* the most pain reduction) and those in the "no labral tear"-category had the lowest NRS change scores at all three time points (Tables 4–6). Statistically significant differences were found for the NRS change scores at all 3 FU-time points only for the combinations of "no labrum tear *vs* labrum degeneration" and "labrum degeneration *vs* labrum degeneration plus tear" (Tables 4–6).

The only other significant NRS change score finding was at 1 day FU for bone marrow edema on the acetabular side of the joint in the anterosuperior quadrant (p = 0.009). Post-hoc unpaired t-tests were then conducted to determine which specific acetabular bone marrow pathology had the highest and lowest change score, showing that patients in the "edema only"-category (N = 2) had the highest NRS change score of 6.0 (SD = 0.71) (*i.e.* the most pain reduction) and patients having no abnormalities at all (N = 78) had the lowest NRS change score of 1.71 (SD = 2.24).

There were no significant differences between the native MR cohort and patients having MR arthrograms in the proportion of patients "improved" or "worse" at any data collection time point.

DISCUSSION

No MRI findings were related to "improvement" post-injection at the 1 month time point. The only MRI finding related to "improvement" at any time point occurred at 1 week in that patients with a normal labrum in the posterosuperior quadrant showed the largest proportion of patients "improved" compared to patients with labral degeneration only or in combination with a labral tear. The main finding regarding the secondary outcome measure of pain reduction was that the "change" in pain-scores was significantly different at all 3 FU-time points for the labral anteroinferior quadrant. The largest pain reduction was reported by patients with labrum degeneration, the smallest by patients with a normal labrum. Articular cartilage and bone marrow abnormalities showed no association with pain reduction. As there were few MRI abnormalities linked to improvement or pain reduction, factors other than imaging findings need to be investigated, *e.g.* the placebo effects.

A study on hip injections with anesthetic by Kivlan et al in patients with femoroacetabular impingement reported a higher percentage of pain relief by patients where acetabular chondral pathologies were detected at hip arthroscopy, regardless of their severity.[6] These authors affirm that a defect of the labrum without additional cartilage damage should not be the cause of the patient's pain. Unlike Kivlan et al, our study did not observe any significant differences in the proportion of patients reporting "improvement" based on the MRI findings of chondral defects. However, Kivlan et al did not use corticosteroids in the injectate and had a much lower mean patient age (29.9 years) than our study (52.2 years). No other studies have found reliable predictors of response to intra-articular corticosteroid injections of the hip.[18,19]

Other studies on intra-articular hip infiltration[3–5] have reported no negative side-effects or complications resulting from the infiltration. In our current study, we observed worsening of the pain in 31.3% of the male patients at 1 month compared to only 8.9% of the female patients. Reasons for this gender discrepancy

Table 4. Baseline and 15 min NRS scores

Anteroinferior labral abnormality	Baseline NRS score (SD)	15 min NRS score (SD)	15 min NRS change score (SD)
No labrum tear (N = 38)	5.43 (1.97)	4.03 (2.67)	1.40 (2.25)
Labrum degeneration (N = 26)	6.53 (1.79)	3.43 (2.91)	3.10 (2.72)
Labrum tear (N = 11)	6.36 (2.26)	2.91 (2.25)	3.45 (2.90)
Labrum degeneration +tear	5.31 (2.50)	3.04 (2.23)	2.27 (2.02)

N = number or patients; NRS = Numerical Rating Scale (for pain);SD, standard deviation.

Table 5. Percentage of patients "improved" and "worse"

	1 day FU			1 week FU			1 month FU		
	Improvement	Worsening	*p*-value	Improvement	Worsening	*p*-value	Improvement	Worsening	*p*-value
Improvement outcome			0.45			0.65			0.37
No labrum tear	23.7% (*N* = 9)	15.8% (*N* = 6)		39.5% (*N* = 15)	10.5% (*N* = 4)		26.3% (*N* = 10)	15.8% (*N* = 6)	
Labrum degeneration	42.3% (*N* = 11)	3.8% (*N* = 1)		53.8% (*N* = 14)	3.8% (*N* = 1)		46.2% (*N* = 12)	15.3% (*N* = 4)	
Labrum tear	36.4% (*N* = 4)	0% (*N* = 0)		36.4% (*N* = 4)	9.1% (*N* = 1)		27.3% (*N* = 3)	0% (*N* = 0)	
Labrum degeneration + tear	29.2% (*N* = 7)	25% (*N* = 6)		41.7% (*N* = 10)	8.3% (*N* = 2)		29.2% (*N* = 7)	25.0% (*N* = 6)	

FU, follow-up;N, number or patients.
*p<0.05.

are unknown. No serious side-effects such as septic arthritis occurred in the cohort studied, however.

One strength of this study is that it is a prospective outcome study, using two simple and validated outcome measures.[14,15] Secondly, this study examines three well-defined categories of intra-articular hip pathologies in patients over age 40. This results in a homogeneous middle age and older patient group with degenerative pathologies, excluding growing disorders or conditions manifest in younger populations. A third strength is that a consensus reading was performed with two highly experienced musculoskeletal radiologists rather than having only one reader or two independent readings to assess reliability. Previous work has shown that the inter rater reliability of interpreting MRI findings can be highly variable depending upon the specific abnormalities.[20,21] These disagreements can usually be resolved with a consensus reading and discussion between the two readers.

The study also has some weaknesses. Our study was limited to a FU-time of 1 month. A longer period of time would be preferable. Further, the NRS and PGIC questionnaires were completed by the patients at home and returned with the postage pre-paid envelope, preventing any influence from the caregiver. Yet, using postal questionnaires and relying on patients to remember to return them after the 1 month data collection time point is another limitation to this study. As reported by Peterson et al,[14] numerous patients fail to return these questionnaires, which reduces the number of participants in the study. A recent study[22] on response rate of patients after a lumbar nerve root injection showed that only about 24% of the patients returned the FU questionnaires, with a worse outcome in the non-responder group. In the present study, the questionnaires were virtually the same as well as the 1 month time frame, suggesting a likely similar questionnaire response rate and leading to a possibility of response bias in a negative way in the present study. Future studies should use SMS or email data collection in order to have longer FU time points with good patient compliance.

An additional weakness of this study is that nearly one-third of the patients did not have arthrography with their hip MRI scans. This may result is some small labral tears being missed on non-arthrographic MRI and leading to an observational bias of abnormal findings and thus, potentially significantly affect the results of this study. Indeed, this study shows paradoxically the best likelihood of response to an intra articular infiltration in patients with a normal labrum, followed by those with a tear or degenerative changes. Moreover, a lack of correlation between the pain reduction and the articular cartilage and especially bone marrow abnormalities such as the presence of edema was observed. Nevertheless, the possibility of improvement due to successful treatment of synovitis secondary to OA highlights an aspect to be studied in future research studies on inflammatory changes identified on arthrographic MRI.

It is interesting that two-thirds of the patients in this study cohort were female and on first glance, this may be considered a weakness. However, this gender ratio is not unusual for

Table 6. Mean NRS change score for the anteroinferior labral specific findings

Change in the NRS mean-score	Mean	Standard deviation	*p*-value	Mean	Standard deviation	*p*-value	Mean	Standard deviation	*p*-value
«labrum degeneration» *vs* «no labrum tear»	3.59	(1.65)	**0.0001***	3.40	(1.90)	**0.001***	3.19	(2.70)	**0.004***
	1.08	(1.85)		1.61	(2.22)		1.34	(2.26)	
«labrum degeneration» *vs* «labrum degeneration + tear»	3.59	(1.65)	**0.002***	3.48	(1.90)	**0.015***	3.19	(2.70)	**0.025***
	1.69	(2.44)		1.96	(2.40)		1.50	(2.39)	
«labrum degeneration» *vs* «labrum tear»	3.59	(1.65)	0.10	3.48	(1.90)	0.71	3.19	(2.70)	0.29
	2.36	(2.72)		3.18	(2.97)		2.09	(3.15)	
«no labrum tear» *vs* «labrum tear»	1.08	(1.85)	0.08	1.61	(2.22)	0.06	1.34	(2.26)	0.38
	2.36	(2.72)		3.18	(2.97)		2.09	(3.15)	
«labrum degeneration + tear» *vs* «no labrum tear»	1.69	(2.44)	0.27	1.96	(2.40)	0.56	1.50	(2.39)	0.79
	1.08	(1.85)		1.61	(2.22)		1.34	(2.26)	
«labrum tear» *vs* «labrum degeneration + tear»	2.36	(2.72)	0.47	3.18	(2.97)	0.20	2.09	(3.15)	0.55
	1.69	(2.44)		1.96	(2.40)		1.50	(2.39)	

N, number or patients; NRS, Numerical Rating Scale (for pain); vs, versus.
*p<0.05.

hip pain sufferers with similar female/male ratios reported in other studies where between 60 and 76% of the cohorts were females.[23–25] Females were also nearly three times more likely to report clinically relevant "improvement" at both 1 day and 1 month post injection compared to males. Other recent studies have found that females were significantly more likely to have positive outcomes for both surgical and non-surgical treatments for hip pain and OA.[26–28] However, none of these previous studies evaluated therapeutic hip infiltrations.

Finally, only imaging findings were compared to treatment outcomes and no other factors such as abnormal physical examination findings or specific complaints in the patient history.

CONCLUSION

No MRI abnormalities were related to overall "improvement" at the 1 month time point. Patients with labral degeneration of the anteroinferior quadrant had higher levels of pain reduction at all-time points. Females were significantly more likely to report "improvement" at 1 day and 1 month post injection.

REFERENCES

1. Kruse DW. Intraarticular cortisone injection for osteoarthritis of the hip. is it effective? is it safe? *Curr Rev Musculoskelet Med* 2008; **1**(3-4): 227–33. doi: https://doi.org/10.1007/s12178-008-9029-0
2. Subedi N, Chew NS, Chandramohan M, Scally AJ, Groves C. Effectiveness of fluoroscopy-guided intra-articular steroid injection for hip osteoarthritis. *Clin Radiol* 2015; **70**: 1276–80. doi: https://doi.org/10.1016/j.crad.2015.07.002
3. Qvistgaard E, Christensen R, Torp-Pedersen S, Bliddal H. Intra-Articular treatment of hip osteoarthritis: a randomized trial of hyaluronic acid, corticosteroid, and isotonic saline. *Osteoarthritis Cartilage* 2006; **14**: 163–70. doi: https://doi.org/10.1016/j.joca.2005.09.007
4. Lambert RGW, Hutchings EJ, Grace MGA, Jhangri GS, Conner-Spady B, Maksymowych WP, et al. Steroid injection for osteoarthritis of the hip: a randomized, double-blind, placebo-controlled trial. *Arthritis Rheum* 2007; **56**: 2278–87. doi: https://doi.org/10.1002/art.22739
5. Kullenberg B, Runesson B, Tuvhag R, et al. Intraarticular corticosteroid injection: pain relief in osteoarthritis of the hip? *J Rheumatol* 2004; **31**: 2265–8.
6. Kivlan BR, Martin RL, Sekiya JK. Response to diagnostic injection in patients with femoroacetabular impingement, labral tears, chondral lesions, and extra-articular pathology. *Arthroscopy: The Journal of Arthroscopic & Related Surgery* 2011; **27**: 619–27. doi: https://doi.org/10.1016/j.arthro.2010.12.009
7. Karrasch C, Lynch S. Practical approach to hip pain. *Med Clin North Am* 2014; **98**: 737–54. doi: https://doi.org/10.1016/j.mcna.2014.03.003
8. Shabestari M, Vik J, Reseland JE, Eriksen EF. Bone marrow lesions in hip osteoarthritis are characterized by increased bone turnover and enhanced angiogenesis. *Osteoarthritis Cartilage* 2016; **24**: 1745–52. doi: https://doi.org/10.1016/j.joca.2016.05.009
9. Englund M, Guermazi A, Roemer FW, Yang M, Zhang Y, Nevitt MC, et al. Meniscal pathology on MRI increases the risk for both incident and enlarging subchondral bone marrow lesions of the knee: the most study. *Ann Rheum Dis* 2010; **69**: 1796–802. doi: https://doi.org/10.1136/ard.2009.121681
10. Hayes CW, Conway WF, Daniel WW. Mr imaging of bone marrow edema pattern: transient osteoporosis, transient bone marrow edema syndrome, or osteonecrosis. *Radiographics* 1993; **13**: 1001–11. doi: https://doi.org/10.1148/radiographics.13.5.8210586
11. Jones A, Doherty M. Intra-Articular corticosteroids are effective in osteoarthritis but there are no clinical predictors of response. *Ann Rheum Dis* 1996; **55**: 829–32. doi: https://doi.org/10.1136/ard.55.11.829
12. Plant MJ, Borg AA, Dziedzic K, Saklatvala J, Dawes PT. Radiographic patterns and response to corticosteroid hip injection. *Ann Rheum Dis* 1997; **56**: 476–80. doi: https://doi.org/10.1136/ard.56.8.476
13. Sutter R, Zubler V, Hoffmann A, Mamisch-Saupe N, Dora C, Kalberer F, et al. Hip MRI: how useful is intraarticular contrast material for evaluating surgically proven lesions of the labrum and articular cartilage? *AJR Am J Roentgenol* 2014; **202**: 160–9. doi: https://doi.org/10.2214/AJR.12.10266
14. Peterson CK, Pfirrmann CWA, Hodler J. The development and implementation of an outcomes database for imaging-guided therapeutic musculoskeletal injections. *Skeletal Radiol* 2014; **43**: 979–84. doi: https://doi.org/10.1007/s00256-014-1881-y
15. Newell D, Bolton JE. Responsiveness of the Bournemouth questionnaire in determining minimal clinically important change in subgroups of low back pain patients. *Spine* 2010; **35**: 1801–6. doi: https://doi.org/10.1097/BRS.0b013e3181cc006b
16. Dietrich TJ, Peterson CK, Brunner F, Hodler J, Puskas GJ, Pfirrmann CWA, et al. Imaging-Guided subacromial therapeutic injections: prospective study comparing abnormalities on conventional radiography with patient outcomes. *AJR Am J Roentgenol* 2013; **201**: 865–71. doi: https://doi.org/10.2214/AJR.12.10094
17. Langenfeld A, Humphreys BK, de Bie RA, Swanenburg J. Effect of manual versus mechanically assisted manipulations of the thoracic spine in neck pain patients: study protocol of a randomized controlled trial. *Trials* 2015; **16**: 233. doi: https://doi.org/10.1186/s13063-015-0763-5
18. Hirsch G, Kitas G, Klocke R. Intra-Articular corticosteroid injection in osteoarthritis of the knee and hip: factors predicting pain Relief—A systematic review. *Semin Arthritis Rheum* 2013; **42**: 451–73. doi: https://doi.org/10.1016/j.semarthrit.2012.08.005
19. Krych AJ, Griffith TB, Hudgens JL, Kuzma SA, Sierra RJ, Levy BA, et al. Limited therapeutic benefits of intra-articular cortisone injection for patients with femoro-acetabular impingement and labral tear. *Knee Surg Sports Traumatol Arthrosc* 2014; **22**: 750–5. doi: https://doi.org/10.1007/s00167-014-2862-3
20. Lechmann M, Rosskopf A, Ehrmann C, Sutter R, Pfirrmann CWA, Peterson CK, et al. Relationship of specific MRI findings to treatment outcomes in patients receiving transforaminal epidural steroid injections. *Skeletal Radiol* 2016; **45**: 1677–85. doi: https://doi.org/10.1007/s00256-016-2487-3
21. Fu MC, Buerba RA, Long WD, Blizzard DJ, Lischuk AW, Haims AH, et al. Interrater and intrarater agreements of magnetic resonance imaging findings in the lumbar spine: significant variability across degenerative conditions. *Spine J* 2014; **14**: 2442–8. doi: https://doi.org/10.1016/j.spinee.2014.03.010
22. Lechmann M, Peterson CK, Pfirrmann CWA, Hodler J. Lumbar nerve root

injections: a prospective cohort outcomes study comparing age- and gender-matched patients who returned an outcomes-based postal questionnaire with patients who did not return the postal questionnaire. *Skeletal Radiol* 2013; **42**: 1429–35. doi: https://doi.org/10.1007/s00256-013-1673-9

23. Maradit Kremers H, Larson DR, Crowson CS, Kremers WK, Washington RE, Steiner CA, et al. Prevalence of total hip and knee replacement in the United States. *J Bone Joint Surg Am* 2015; **97**: 1386–97. doi: https://doi.org/10.2106/JBJS.N.01141
24. Nelson AE, Stiller JL, Shi XA, Leyland KM, Renner JB, Schwartz TA, et al. Measures of hip morphology are related to development of worsening radiographic hip osteoarthritis over 6 to 13 year follow-up: the Johnston County osteoarthritis project. *Osteoarthritis Cartilage* 2016; **24**: 443–50. doi: https://doi.org/10.1016/j.joca.2015.10.007
25. Foley B, Cleveland RJ, Renner JB, Jordan JM, Nelson AE. Racial differences in associations between baseline patterns of radiographic osteoarthritis and multiple definitions of progression of hip osteoarthritis: the Johnston County osteoarthritis project. *Arthritis Res Ther* 2015; **17**: 366. doi: https://doi.org/10.1186/s13075-015-0806-z
26. Mannion AF, Impellizzeri FM, Naal FD, Leunig M. Women demonstrate more pain and worse function before THA but comparable results 12 months after surgery. *Clin Orthop Relat Res* 2015; **473**: 3849–57. doi: https://doi.org/10.1007/s11999-015-4479-3
27. Eyles JP, Lucas BR, Patterson JA, Williams MJ, Weeks K, Fransen M, et al. Does clinical presentation predict response to a nonsurgical chronic disease management program for endstage hip and knee osteoarthritis? *J Rheumatol* 2014; **41**: 2223–31. doi: https://doi.org/10.3899/jrheum.131475
28. Clohisy JC, Ackerman J, Baca G, Baty J, Beaulé PE, Kim Y-J, et al. Patient-Reported outcomes of Periacetabular osteotomy from the prospective anchor cohort study. *J Bone Joint Surg Am* 2017; **99**: 33–41. doi: https://doi.org/10.2106/JBJS.15.00798