Received:
11 May 2017

Revised:
22 June 2017

Accepted:
19 July 2017

<https://doi.org/10.1259/bjr.20170345>

Cite this article as:

Lee SH, Yun SJ, Jo HH, Kim DH, Song JG, Park YS. Direct shoulder magnetic resonance arthrography for superior labral anterior-to-posterior (SLAP) and Bankart lesions: investigation into the appropriate dose and level of local anesthesia. *Br J Radiol* 2017; **90**: 20170345.

FULL PAPER

Direct shoulder magnetic resonance arthrography for superior labral anterior-to-posterior (SLAP) and Bankart lesions: investigation into the appropriate dose and level of local anesthesia

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Objective: To compare contrast leakage, pain score, image quality and diagnostic performance at different doses and levels of local anaesthesia for direct shoulder magnetic resonance arthrography.

Methods: Patients ($n = 157$) were prospectively enrolled and allocated to Group 1 (no local anaesthetic), Group 2 (local anaesthesia to subcutaneous fat level; lidocaine 1–2 ml), Group 3 (to deltoid muscle level; 3–5 ml), or Group 4 (to subscapularis muscle level; 6–8 ml). We evaluated the frequency of contrast leakage, periprocedural/post-procedural pain, contrast-to-noise ratio of the intra-articular signal, and subjective image noise/image sharpness. Radiological diagnoses of superior anterior-to-posterior (SLAP) and Bankart lesions were assessed. All data were analysed by one-way analysis of variance/Kruskal–Wall, χ^2 /Fisher's exact and DeLong's tests.

Results: The frequency of contrast leakage from the injection path and subjective image noise were significantly

lower in Groups 1 and 2 than in Groups 3 and 4 ($p = 0.001$ – 0.04). Periprocedural/postprocedural pain scores among Groups 2–4 were similar and lower than those of Group 1. The contrast-to-noise ratio ($p = 0.11$ – 0.97) and image sharpness ($p = 0.12$ – 0.43) were similar among Groups 2–4 and significantly lower than those of Group 1 ($p = 0.001$ – 0.02). The diagnostic performance for the assessment of superior anterior-to-posterior and Bankart lesions was better in Groups 2–4 than in Group 1, although there were no significant differences ($p = 0.23$ – 0.99).

Conclusion: Local anaesthesia with 1–2 ml lidocaine at subcutaneous fat level reduced pain and provided optimal image quality in direct shoulder magnetic resonance arthrography.

Advances in knowledge: This method can increase image quality, reduce periprocedural/postprocedural pain and potentially reduce the need for re-examination.

INTRODUCTION

Direct magnetic resonance arthrography (MRA) of the shoulder is considered a safer and more accurate imaging technique for evaluation of internal shoulder joint abnormalities than conventional MR imaging.¹ The procedure is mainly performed for distension of the glenohumeral joint, using intra-articular injection of dilute gadolinium, for easier visualization of the anatomy via better delineation of the articular surfaces.¹ In particular, the advantage of MRA has been demonstrated in the assessment of labral tears and capsular/ligamentous injuries in younger patients.¹

For intra-articular administration of diluted gadolinium, multiple techniques (anteroinferior, rotator cuff interval, and posterior approaches) and modalities (fluoroscopy and ultrasound) have been established.^{1–4} Recently, ultrasound-guided injection has been recommended because it is an accurate, quick and radiation-free modality; however, fluoroscopy is still used in most institutions, being a low-cost and familiar technique.⁵

Despite the low morbidity and complication rates for direct MRA of the shoulder, pain perception remains an important issue that can discourage patients from

undergoing a valuable diagnostic and problem-solving imaging method. Fluoroscopy-guided anteroinferior technique can be painful because the needle traverses the subscapularis tendon.⁶ Although pain completely resolves within a few days, the technique may cause motion artefacts during image acquisition in MRA, resulting in false-negative or false-positive interpretation.⁷ In addition, anterior stabilizing structures such as the deltoid and subscapularis muscles can appear distorted on MRA along the course of the needle.⁶

Currently, there are no definite recommendations for the dose or tissue level of local anaesthesia for MRA of the shoulder. Therefore, these parameters for local anaesthesia using lidocaine are solely based on the preference of the radiologist. We hypothesized that different doses and levels of local anaesthesia may affect not only the pain score but also the image quality and diagnostic performance of MRA of the shoulder. To test our hypothesis, this study compared pain score, image quality and diagnostic performance at different doses and levels of local anaesthesia for direct MRA of the shoulder.

METHODS AND MATERIALS

Study population

Our Institutional Review Board approved this study and we obtained written, informed consent from all patients. At our institution, younger patients (<40 years old) with symptoms of instability or a history of recurrent shoulder dislocation are usually referred for MRA. Because shoulder stabilization transfers from the labrum to the rotator cuff with advancing years (≥ 40 years), the value of arthrography in older patients is limited.⁸ Inclusion criteria were (1) MRA performance at our institution with a fluoroscopy-guided anteroinferior approach, (2) availability for telephone interview, (3) subsequent arthroscopy within 3 months of the MRA and (4) availability of a detailed arthroscopic report. Exclusion criteria were (1) history of surgery of the shoulder before MRA, (2) repeated MRA of the same shoulder and (3) MRA of both shoulders on the same day. We prospectively examined 165 cases of direct shoulder MRA between August 2016 and March 2017. Patients were referred for MRA for symptoms of instability or recurrent shoulder dislocation. Eight patients were excluded: five had undergone previous surgery in the shoulder before undergoing MRA, two had undergone repeated MRA of the same shoulder and one had undergone MRA of both shoulders on the same day. Finally, 157 patients (147 males and 10 females; age range, 19–39 years; mean age, 27.2 years; 92 right and 65 left shoulders) were included in this study. Patients were randomly assigned into one of four groups by one physician: Group 1 (no local anaesthetic), Group 2 (local anaesthesia to subcutaneous fat level with 1–2 ml lidocaine), Group 3 (local anaesthesia to deltoid muscle level with 3–5 ml lidocaine) and Group 4 (local anaesthesia to subscapularis muscle level with 6–8 ml lidocaine).

Image analysis

Two junior board-certified radiologists blinded to all patient data evaluated quantitative and qualitative image qualities on a Picture Archiving and Communication System y consensus. Quantitative image quality was evaluated by assessing the

Figure 1. Region of interests (ROIs) for contrast-to-noise ratio analysis in left shoulder MR arthrography for a 23-year-old male with instability. Axial image of the T_1 -turbo spin echo (left) and axial image of the proton-density fat-suppressed sequences (right) at the level of the axillary recess of the shoulder. ROI1 and ROI4, intra-articular joint fluid; ROI2 and ROI5, deltoid muscle; ROI3 and ROI 6, background air.

contrast-to-noise ratio (CNR) of the intra-articular (glenohumeral joint) signal. Signal intensity was assessed by measuring regions of interest (ROIs) in the joint space (intra-articular fluid) and in the adjacent muscle tissue (deltoid muscle) at each time point using both T_1 -turbo spin echo (TSE) and proton-density (PD) fat-suppressed (FS) axial images. Signal intensity (SI) of the intra-articular fluid was measured in the axillary recess of the shoulder adjacent to the articular surface of the humeral head.⁹ ROIs were placed at identical locations on the T_1 -TSE and PD-FS images and had areas of 5–10 mm². The standard deviation (SD) of the background air outside of the patient was regarded as image noise (area of circle, 5–10 mm²) (Figure 1). To avoid volume artefacts, SIs of the joint space and deltoid muscle, and SD of the background air were measured three times, and average values were used. CNR of the intra-articular signal was calculated using the following equation:¹⁰

$$\text{CNR}_{\text{intra-articular signal}} = \frac{(\text{SI}_{\text{intra-articular joint fluid}} - \text{SI}_{\text{deltoid muscle}})}{\text{SD}_{\text{background air}}}$$

ROI measurements were evaluated three times and the mean value was obtained. Qualitative image quality was determined by assessing subjective image noise (considering distorted signal intensity in subcutaneous fat, muscle and bone) (Figure 2) and the degree of motion (Figure 3) of the intra-articular structures of the shoulder. When analysing the images for motion, if a sequence had been repeated, the one containing images with less motion was used because it would have been reviewed during interpretation of the study (Table 1). Among the routine MR sequences, the sequence containing images with the most motion (the highest motion grade) was the one used to assign the motion grade. The radiologists also evaluated the simple “presence” or “absence” of contrast leakage into locations related (Figure 2) and unrelated to the injection path (Figure 4).

Figure 2. Examples of subjective image noise and contrast leakage related to injection path in shoulder MR arthrography (MRA). (a) Axial T_1 weighted (left) and proton-density fat-suppressed (PD-FS) (right) images from a 20-year-old male with a history of recurrent shoulder dislocation demonstrating subtle distorted signal intensity (SI) (arrows) due to the injection throughout the shoulder. The subjective image noise score was 0. (b) Axial T_1 weighted (left) and PD-FS (right) images from a 21-year-old male with instability demonstrating distorted SI on subcutaneous fat level (arrows). The scores of the subjective image noise is 1. There is no contrast leakage related to injection path. (c) Axial T_1 weighted (left) and PD-FS (right) images from a 24-year-old male with a history of recurrent shoulder dislocation demonstrating distorted SI on subcutaneous fat (arrows) and deltoid muscle (arrow-head). The score of the subjective image noise is 2. There is no contrast leakage related to injection path. (d) Axial T_1 weighted (left) and PD-FS (right) images from a 21-year-old male with instability demonstrating distorted SI on subcutaneous fat (arrows) and deltoid muscle (arrowheads). The scores of the subjective image noise is 2. The distorted SI in deltoid muscle shows high SI on both T_1 weighted and PD-FS images, indicating contrast leakage related to injection path. (e) Axial T_1 weighted (left) and PD-FS (right) images from a 23-year-old male with instability demonstrating distorted SI on subcutaneous fat (arrows), deltoid muscle (open arrowheads) and subscapularis muscle (arrowheads). The scores of the subjective image noise is 2. The distorted SI in deltoid muscle and subscapularis muscle show high SI on both T_1 weighted and PD-FS images, indicating contrast leakage related to injection path. (f) Axial T_1 weighted (left) and PD-FS (right) images from a 38-year-old male with instability demonstrating distorted SI on subcutaneous fat (arrows) and humeral head (arrowheads). The scores of the subjective image noise is 3. There is no contrast leakage related to injection path.

Figure 3. Examples of image sharpness (motion grade) in shoulder MR arthrography (MRA). (a) Axial T_1 weighted (left) and proton-density fat-suppressed (PD-FS) (right) images from a 34-year-old male with a history of recurrent anterior dislocations, showing no motion artefacts (image sharpness score: 0). Both reviewers correctly diagnosed Bankart lesion (arrow). (b) Axial PD-FS images (left and right) from a 19-year-old female with a history of recurrent anterior dislocations, showing minimal motion artefact that does not affect the diagnostic quality of this image (The score of the image sharpness: 1). Both reviewers correctly diagnosed Bankart lesion (arrow). (c) Axial PD-FS images (left and right) from a 32-year-old male with instability, showing a moderate degree of motion artefact (arrowheads, left), diminishing the diagnostic quality of the image (The score of the image sharpness: 2). However, both reviewers correctly diagnosed superior labral anterior-to-posterior type II lesion (arrows, right). (d) Axial PD-FS image from a 20-year-old male with instability, showing a severe grade of motion artefact due to the pain, rendering the image non-diagnostic (The score of the image sharpness: 3).

To compare the diagnostic performances of the two sequences, 157 direct shoulder MRAs were independently reviewed by one senior board-certified radiologist and one orthopaedic shoulder surgeon blinded to all patient data. To diagnose SLAP or Bankart lesions, the reviewers evaluated the type of SLAP lesion (Types I–IV).¹¹ Osseous fractures of the anteroinferior glenoid rim reflected bony Bankart lesions, while their absence indicated cartilaginous Bankart lesions.¹² All MR diagnoses were compared to reference results of arthroscopic findings performed by an orthopaedic shoulder surgeon.

Statistical analysis

All data were analysed using MedCalc (version 12.3.0; Mariakerke, Belgium). There were four components to the statistical analysis: (1) comparison of continuous variables using one-way analysis of variance (ANOVA) with Bonferroni post hoc test

Table 1. Structured direct shoulder magnetic resonance arthrography reports

Analysed finding and rating	Description
Subjective image noise	
0	Little noise (no or subtle distorted signal intensity)
1	Optimum noise (distorted signal intensity in subcutaneous fat)
2	Noisy but permit evaluation (distorted signal intensity in subcutaneous fat and muscle)
3	Too much noise, which degrades the image quality (distorted signal intensity in soft tissue and bone)
Image sharpness	
0	No motion artefact
1	Minimal motion artefact present but not degrading image interpretation
2	Moderate motion present, degrading interpretation, but image is still diagnostic
3	Severe motion artefact present, rendering the image non-diagnostic
Contrast leakage related to injection path	
0	Absence
1	Presence
Contrast leakage unrelated to injection path	
0	Absence
1	Presence

and non-continuous variables using Kruskal–Wallis test with Mann–Whitney U -test as post hoc test, (2) calculation of the diagnostic accuracy (sensitivity, specificity, accuracy, positive predictive value and negative predictive value) of each reviewer, using a Pearson χ^2 test or Fisher's exact test, 3) comparison of diagnostic accuracy between each group using DeLong's test,¹³ and 4) assessment of interobserver agreement using an intraclass correlation coefficient with a 95% confidence interval (CI). Intraclass correlation coefficients 0–0.20 indicated poor agreement, 0.21–0.40 indicated fair agreement, 0.41–0.60 indicated moderate agreement, 0.61–0.80 indicated good agreement and 0.81–1.00 indicated excellent agreement.¹⁴ p values < 0.05 were considered statistically significant.

RESULTS

Patient demographics

Baseline characteristics of all patients and each group are described in Table 2. Age, sex, history of shoulder trauma within the last year, contrast leakage unrelated to injection path,

Figure 4. Examples of contrast leakage unrelated to the injection path in shoulder MR arthrography. (a) Axial T_1 weighted (left), axial proton-density fat-suppressed (PD-FS) (middle) and sagittal PD-FS (right) images from a 32-year-old male with an instability, showing contrast leakage (arrows) through the surface between the infraspinatus muscle and teres minor muscle. (b) Axial T_1 weighted (left), axial PD-FS (middle) and sagittal PD-FS (right) images from a 21-year-old male with an instability, showing contrast leakage (arrows) through the subscapular recess. (c) Axial T_1 weighted (left), axial PD-FS (middle) and sagittal PD-FS (right) images from a 23-year-old male with an instability, showing contrast leakage (arrows) through the undersurface of the subscapularis muscle.

procedural time and level of difficulty were not significantly different among the four groups ($p = 0.18$ – 0.93). Although contrast leakage related to injection path of Group 3 and 4 were significantly higher than that of Group 1 ($p = 0.04$ and 0.007 , respectively) and Group 2 ($p = 0.04$ and 0.006 , respectively) Contrast leakage related to injection paths between Groups 3 and 4 were not significantly different ($p = 0.61$).

Among the 157 patients who underwent direct shoulder MRA, shoulder arthroscopy revealed the presence of SLAP lesions in 88 patients (Type II, 86; and Type IV, 2) and Bankart lesions in 69 patients (67 cartilaginous and 2 osseous). In addition, we detected rotator cuff tear in 3 of the 157 patients (low grade partial tear of the subscapularis). Other shoulder pathologies were not observed. The distribution of the shoulder pathologies was not significantly different among the four groups ($p = 0.77$ – 0.78). The mean interval between direct shoulder MRA and arthroscopy was 39.2 days (range, 15–89 days).

Pain score

Other than pain, there were no other reported complications. The mean level of the baseline pain was not significantly different among the four groups ($p = 0.53$). However, the mean pain level immediately after injection in Group 1 was significantly higher than that in Groups 2 ($p = 0.002$), 3 ($p = 0.003$) and 4 ($p = 0.032$). There was no significant difference among Groups 2–4, ($p = 0.75$ – 0.87). The mean pain level 1 day following the injection in Group 1 was significantly higher than that in Groups 2 ($p = 0.011$),

3 ($p = 0.013$) and 4 ($p = 0.033$). There was no significant difference among the Groups 2–4 ($p = 0.66$ – 0.98). Also, the mean pain level 2 days following the injection in Group 1 was significantly higher than that in Groups 2 ($p = 0.032$), 3 ($p = 0.033$) and 4 ($p = 0.032$). There was no significant difference among the Groups 2–4 ($p = 0.72$ – 0.96). The mean pain level 4 days following the injection was not significantly different among the four groups ($p = 0.56$) (Figure 5).

Quantitative and qualitative image quality

The mean CNR for the intra-articular signal was the highest in Group 4 for T_1 -TSE and the PD-FS images (Table 2). In post-hoc analysis, the mean CNR in Group 4 for T_1 -TSE images was significantly higher than that in Group 1 ($p = 0.02$), but not in Groups 2 ($p = 0.55$) and 3 ($p = 0.97$). In addition, the mean CNR in Group 4 for the PD-FS image was significantly higher than that in Group 1 ($p = 0.008$), but not in Groups 2 ($p = 0.11$) and 3 ($p = 0.73$).

In terms of qualitative image noise, the mean value of subjective image noise in Group 1 was the lowest among the groups and significantly lower than that in Groups 2–4 in post hoc analysis ($p = 0.001$ – 0.013). The mean value of subjective image noise in Group 2 was lower than that in Groups 3 and 4 ($p < 0.001$). The mean value of image sharpness in Group 4 was the highest among the groups and significantly higher than that in Group 1 ($p < 0.001$). However, it was not significantly different from that in Group 2 ($p = 0.12$) or Group 3 ($p = 0.43$) in post hoc analysis.

Table 2. Overall characteristics of study patients in each local anaesthetic group

Characteristics	Overall (<i>n</i> = 157)	Local anaesthetic group				<i>p</i> -value
		Group 1 (<i>n</i> = 39)	Group 2 (<i>n</i> = 40)	Group 3 (<i>n</i> = 41)	Group 4 (<i>n</i> = 37)	
Age (yr), mean (SD)	27.2 (5.2)	27.0 (5.2)	27.8 (5.1)	27.7 (5.3)	27.0 (5.5)	0.19
Sex, mean (SD)						
Male, <i>n</i> (%)	147 (93.6)	36 (92.3)	38 (95.0)	39 (95.1)	34 (91.9)	0.90
Female, <i>n</i> (%)	10 (6.4)	3 (7.7)	2 (5.0)	2 (4.9)	3 (8.1)	
Side						
Right, <i>n</i> (%)	92 (58.6)	28 (71.8)	25 (62.5)	23 (56.1)	16 (43.2)	0.38
Left, <i>n</i> (%)	65 (41.4)	21 (28.2)	15 (37.5)	18 (43.9)	21 (56.8)	
History of shoulder trauma within 1 year, <i>n</i> (%)	52 (33.1)	15 (38.5)	12 (30.0)	13 (31.7)	12 (32.4)	0.93
Contrast leakage related to injection path, <i>n</i> (%)	14 (8.9)	0 (0)	0 (0)	6 (14.6)	8 (21.6)	0.004
Contrast leakage unrelated to injection path, <i>n</i> (%)	11 (7.0)	2 (5.1)	2 (5.0)	3 (7.3)	4 (10.8)	0.73
Procedure time (s), mean (SD)	245.3 (76.1)	243.8 (75.7)	240.7 (72.3)	254.0 (77.8)	245.0 (78.7)	0.90
Level of difficulty						
Easy, <i>n</i> (%)	152 (96.8)	37 (94.9)	40 (100)	40 (97.6)	35 (94.6)	0.48
Difficult, <i>n</i> (%)	5 (3.2)	2 (5.1)	0 (0)	1 (2.4)	2 (5.4)	
Baseline pain, mean (SD)	3.6 (2.4)	3.3 (2.1)	3.7 (2.5)	3.5 (2.3)	3.6 (2.4)	0.53
Shoulder pathology						
SLAP lesion, <i>n</i> (%)	88 (56.1)	20 (51.3)	21 (52.5)	25 (61.0)	22 (59.5)	0.77
Bankart lesion, <i>n</i> (%)	69 (43.9)	19 (48.7)	19 (47.5)	16 (39.0)	15 (40.5)	0.77
Rotator cuff tear, <i>n</i> (%)	3 (1.9)	1 (2.6)	1 (2.5)	0 (0)	1 (2.7)	0.78
Contrast-to-noise ratio						
T1-TSE, mean (SD)	132.6 (38.7)	122.5 (41.2)	137.7 (39.5)	142.5 (36.3)	142.8 (37.2)	<0.001
PD-FS, mean (SD)	80.8 (25.9)	72.9 (27.5)	80.1 (25.8)	87.5 (24.9)	89.5 (25.2)	<0.001
Subjective image noise, mean (SD)	1.5 (0.5)	0.9 (0.3)	1.1 (0.4)	1.6 (0.6)	2.2 (0.7)	<0.001
Image sharpness, mean (SD)	1.7 (0.6)	2.1 (0.8)	1.4 (0.6)	1.3 (0.6)	1.2 (0.5)	<0.001

FS, fat suppressed; PD, proton density; SD, standard deviation; SLAP, superior labral anterior-to-posterior; TSE, turbo spin echo.

Diagnostic performance for the assessment of SLAP and bankart lesions

Tables 3 and 4 show the diagnostic performance for the assessment of SLAP and Bankart lesions assessed by each reviewer. The sensitivity ($p = 0.50$ – 0.96), specificity ($p = 0.23$ – 0.95) and accuracy ($p = 0.23$ – 0.67) for the diagnosis of SLAP lesions were not significantly different among the four groups between reviewers 1 and 2. Although there was no significant difference, the accuracy in Group 1 was below 90%. In Groups 2 and 3 the diagnostic accuracy was equal to or above 95% for both reviewers.

The sensitivity ($p = 0.43$ – 0.99), specificity ($p = 0.47$ – 0.95) and accuracy ($p = 0.32$ – 0.89) for the diagnosis of Bankart lesions were not significantly different among the four groups between reviewers 1 and 2. Although there was no significant difference, the accuracy in Group 1 was the lowest. In Groups 2 and

3 the diagnostic accuracy was equal to or above 95% for both reviewers.

DISCUSSION

According to our study, the periprocedural and postprocedural pain scores among Groups 2–4 were similar and lower than those of Group 1. Although there was no significant difference in the diagnostic performance for the assessment of SLAP and Bankart lesions among the four groups, performance was better in Groups 2, 3 and 4 than in Group 1. Additionally, in considering subjective image noise and contrast leakage along the injection path, we concluded that the procedures in Group 2 (local anaesthesia to subcutaneous fat level with lidocaine 1–2 ml) were the best choice for MRA of the shoulder, because Groups 3 and 4 showed significantly higher subjective image noise and contrast leakage along the injection path (Table 5).

Figure 5. Mean pain scores at each time phase among the sub-groups. Group 1 = no local anaesthetic; Group 2 = local anaesthesia to subcutaneous fat level with 1-2 ml lidocaine; Group 3 = local anaesthesia to deltoid muscle level with 3-5 ml lidocaine; Group 4 = local anaesthesia to subscapularis muscle level with 6-8 ml lidocaine.

Debates regarding the use of lidocaine as a local anaesthetic, its dose and the tissue level of local anaesthesia are ongoing. A Few studies^{15,16} have concluded that local anaesthesia does not lower pain intensity and have demonstrated that use of local anaesthesia may raise costs and increase the rate of major adverse reactions related to lidocaine, such as anaphylaxis. However, these studies,^{15,16} which emphasized the benefit of not using local anaesthetics, did not evaluate motion grade, diagnostic performance, exact frequency of adverse reactions, or procedure times. Local anaesthesia for anaesthetizing the skin and soft tissues is still administered in most institutions.¹⁷ We thought that the reason for this might be related to patient comfort. Regarding the level of anaesthesia, a recent review recommended administering local anaesthesia along the spinal needle tract.⁶ However, the required depth of local anaesthesia administered by the radiologist was not clear. Our study is important because it is the first study on the use of lidocaine as a local anaesthetic, its dose, and the tissue level of anaesthesia. In addition, we evaluated motion grade, diagnostic performance, exact frequency of adverse reactions, and procedure times among the different groups.

When performing direct shoulder MRA it is important to control pain to avoid motion artefacts during image acquisition.⁷ It was agreed that the median image sharpness score was the lowest in Group 1 and the highest in Group 4. Lower quality images might increase the need for re-examination of the shoulder by MR or MR arthrography. Thus, we thought that it was important to obtain an accurate diagnosis from better quality MR arthrographic images, although omitting the use of anaesthesia could reduce costs for patients.

The causes of periprocedural pain resulting from direct shoulder MRA are not completely understood. Irritation of the synovia due to the contrast medium may not be the main reason. A previous

Table 3. Diagnostic performance for analysis of SLAP lesions for each reviewer according to local anaesthetic group

SLAP lesion	Reviewer 1				P^a	Reviewer 2				P^a
	Group 1	Group 2	Group 3	Group 4		Group 1	Group 2	Group 3	Group 4	
Sensitivity	95.2 (76.2–99.9)	100 (85.8–99.9)	95.2 (76.2–99.9)	100 (84.6–100)	0.50–0.96	95.2 (76.2–99.9)	95.8 (78.9–99.9)	95.2 (76.2–99.9)	100 (84.6–100)	0.53–0.69
Specificity	88.9 (65.3–98.6)	93.8 (70.0–99.8)	95.0 (75.1–99.9)	93.3 (68.1–99.8)	0.54–0.95	83.3 (58.6–96.4)	93.8 (70.0–99.8)	100 (83.2–100)	86.7 (59.5–98.3)	0.23–0.91
PPV	90.9 (73.0–97.4)	96.0 (78.3–99.4)	95.2 (74.7–99.3)	95.7 (76.8–99.3)	0.50–0.87	87.0 (70.3–95.0)	95.8 (77.5–99.4)	100 (NA)	91.7 (75.2–97.6)	0.25–0.88
NPV	94.1 (70.1–99.1)	100 (NA)	95.0 (73.7–99.2)	100 (NA)	0.56–0.98	93.8 (68.7–99.0)	93.8 (68.7–99.0)	95.4 (74.7–99.3)	100 (NA)	0.19–0.63
Accuracy	92.3 (79.0–98.4)	97.5 (85.9–99.9)	95.1 (83.5–99.4)	97.3 (81.8–99.1)	0.40–0.62	89.7 (75.6–97.1)	95.0 (82.8–99.3)	97.6 (87.2–99.9)	94.6 (80.0–98.9)	0.23–0.67

NA, not applicable; NPV, negative predictive value; PPV, positive predictive value; SLAP, superior labral anterior-to-posterior. Data are percentages and 95% confidence interval in parenthesis.

^aRange of *p*-values when comparing parameters of each group using DeLong's test.

Table 4. Diagnostic performance for analysis of Bankart lesions assessed by each reviewer according to local anaesthetic group

SLAP lesion	Reviewer 1				P^a	Reviewer 2				P^a
	Group 1	Group 2	Group 3	Group 4		Group 1	Group 2	Group 3	Group 4	
Sensitivity	94.4 (72.7–99.9)	100 (79.4–100)	95.0 (75.1–99.9)	100 (78.2–100)	0.52–0.98	94.4 (72.7–99.9)	93.8 (70.0–99.8)	95.0 (75.1–99.9)	100 (78.2–100)	0.43–0.56
Specificity	90.5 (69.6–98.8)	95.8 (78.9–99.9)	100 (83.9–100)	95.5 (77.2–99.9)	0.47–0.95	90.5 (69.6–98.8)	95.8 (78.9–99.9)	95.2 (76.2–99.9)	90.9 (70.8–98.9)	0.53–0.95
PPV	89.5 (69.4–97.0)	94.1 (70.1–99.1)	100 (NA)	93.8 (68.9–99.0)	0.47–0.96	89.5 (69.4–97.0)	93.8 (68.7–99.0)	95.0 (73.7–99.2)	88.2 (66.7–96.6)	0.46–0.95
NPV	95.0 (73.8–99.2)	100 (NA)	95.5 (75.7–99.3)	100 (NA)	0.58–0.99	95.0 (73.8–99.2)	95.8 (77.5–99.4)	95.2 (74.7–99.3)	100 (NA)	0.44–0.98
Accuracy	92.3 (79.3–98.5)	97.5 (87.5–100)	97.6 (87.0–99.9)	97.3 (86.5–100)	0.32–0.89	92.3 (79.3–98.5)	95.0 (82.8–99.3)	95.1 (83.5–99.4)	94.6 (83.0–99.6)	0.48–0.68

NA, not applicable; NPV, negative predictive value; PPV, positive predictive value; SLAP, superior labral anterior-to-posterior.

Data are percentages and 95% confidence interval *in parenthesis*.

^aRange of p -values when comparing parameters of each group using DeLong's test.

study has shown that inflammatory changes after arthrography result from infiltrating leukocytes and minimal synovial hyperplasia. This occurs after the administration of saline, and iodinated and gadolinium-containing contrast mediums.^{18,19} The investigators concluded that the trauma from needle puncture and joint distension, but not the contrast medium, are responsible for synovial reactions. For this reason, there is still controversy surrounding the use of a needle for local anaesthesia along the tract and whether it could lead to an increased risk of inflammatory changes, infection, and/or allergic reaction.²⁰ However, such inflammatory changes seem to be reversible and transient, since they are undetectable after 4 days.²¹ Based on these findings, we administered local anaesthesia to different tissue levels and concluded that local anaesthesia to the subcutaneous fat level was the most appropriate, and might not cause synovial reactions. In addition, local anaesthesia to the subcutaneous fat level has the advantage over no anaesthesia of significantly lowering pain immediately after injection.

The postprocedural pain may be due in part to the gradual influx of fluid, which is in turn dependent on the osmolality of the contrast material.²² In our study, postprocedural pain of Groups 2–4 were lower than that of Group 1. Thus, the effect of the osmolality on the sensation of pain could be minimal. Although osmolality has a minimal effect on postprocedural pain, it is important to inform the patient about the delayed onset of shoulder pain to decrease his or her anxiety after leaving the radiology department.

In our study, the NRS was used as the subjective pain score instead of a visual analogue scale (VAS), which are the main pain rating scales in clinical use.^{23–25} In a recent review of pain rating scales, the advantages and disadvantages of each method were discussed, and it was concluded that the VAS is the most difficult statistical tool to use and has the highest failure rate.²³ Furthermore, it was suggested that the NRS and VRS methods are both appropriate for use in clinical practice and easily accepted by the patient, but NRS is more sensitive and yields data that can be statistically analyzed.²³ In previous studies,^{15,16} emphasizing the benefits of no anaesthesia, VAS was used as the pain rating scale. The differences among the pain rating scales could affect the results.

This study has several limitations. First, we used a fluoroscopy-guided anteroinferior trans-subscapularis approach only (not ultrasound-guided or a rotator interval or posterior approach). Particularly, the use of ultrasound in the musculoskeletal system has only recently increased and ultrasound-guided intra-articular injection would have been fundamental.⁵ Therefore, our results might have been different if other approaches had been used. Second, we did not evaluate other variables related to the pain such as placebo effect of local anaesthesia, underlying patient anxiety and technologist factor. Koivikko, et al¹⁶ demonstrated that local anaesthesia has a placebo effect and may affect patient expectations regarding a forthcoming procedure, that is, it may be indicative of a painful procedure, which could exaggerate a patient's perception of pain. However, in our study, periprocedural pain was reduced rather than increased according

Table 5. Compare the contrast leakage, pain score, image quality, and diagnostic performance with different local anaesthesia dose and level

Method ^a	Contrast leakage related to injection path	Pain score immediately after injection	Contrast-to-noise ratio (CNR)	Subjective image noise	Image sharpness	Diagnostic performance
Group 1
Group 2
Group 3
Group 4

= more favourable (low frequency of contrast leakage, low pain score, high CNR, low subjective image noise, high image sharpness, high diagnostic performance); = less favourable (high frequency of contrast leakage, high pain score, low CNR, high subjective image noise, low image sharpness, low diagnostic performance)

^aGroup 1 = no local anaesthetic; Group 2 = local anaesthesia to subcutaneous fat level with 1–2 ml lidocaine; Group 3 = local anaesthesia to deltoid muscle level with 3–5 ml lidocaine; Group 4 = local anaesthesia to subscapularis muscle level with 6–8 ml lidocaine.

to the pain scales of Groups 2, 3 and 4; we thought that local anaesthesia might help ensure patient comfort and compliance. Third, the reviewers could not be completely blinded to the use and dose of the local anaesthetic because the presence/absence and extent of subcutaneous oedema or extra-articular leakage could indicate that a local anaesthetic had been used. Fourth, interpretation bias could have affected the arthroscopic results, as the orthopaedic surgeon was not blinded to the findings of direct shoulder MRA. However, it would not be possible to blind the orthopaedic surgeon to the findings of direct shoulder MRA before performing arthroscopy. Finally, we did not enrol a placebo group (sham local anaesthetic injection with normal

saline), and thus, we could not perform a comparison between a placebo group and a group receiving a local anaesthetic injection. For more confirmative results and conclusions, further evaluation including a placebo group may be needed.

In conclusion, our study revealed that the optimal image quality and diagnostic performance for the assessment of SLAP and Bankart lesions in direct shoulder MRA was achieved under local anaesthesia to the subcutaneous fat level with lidocaine 1–2 ml. This method can increase image quality, reduce periprocedural/postprocedural pain and potentially reduce the need for re-examination.

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