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Original article

Subacromial anaesthetics increase asymmetry of scapular kinematics in patients with subacromial pain syndrome

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ABSTRACT

Background: Subacromial pain syndrome (SAPS) and scapular dyskinesis are closely associated, but the role of pain is unknown. We hypothesized that pain results in asymmetrical scapular kinematics, and we expected more symmetrical kinematics after infiltration of subacromial anaesthetics.
Objective: To investigate the effect of subacromial anaesthetics on scapular kinematics in patients with SAPS.
Design: Observational cohort study.
Methods: We evaluated shoulder kinematics in 34 patients clinically and radiologically (magnetic resonance arthrography) identified with unilateral SAPS using three-dimensional electromagnetic motion analysis (Flock of Birds). Scapular internal rotation, upward rotation and posterior tilt of the affected shoulder were compared with the kinematics of the unaffected shoulder and following subacromial anaesthetics. Additionally, the association of pain (Visual Analogue Scale, VAS) and scapular rotation was analysed.
Results: Compared with the contralateral healthy shoulder, 5° more (95% CI 0.4–9.7, $p = 0.034$) scapular internal rotation was observed in the affected shoulder at 110–120° of abduction. Following subacromial anaesthetics in the affected shoulder, internal rotation increased (2°, 95% CI 0.5–3.9, $p = 0.045$) and posterior tilt decreased (3°, 95% CI 1.5–5.0, $p = 0.001$) at 110–120° of abduction. Less scapular upward rotation was significantly associated with higher pain scores before infiltration ($R = 0.45$, $p = 0.013$).
Conclusions: More scapular internal rotation was observed in affected shoulders of patients with SAPS compared with unaffected shoulders. Subacromial infiltration did not restore kinematics toward symmetrical scapular motion. These findings suggest that subacromial anaesthesia is not an effective means to instantly restore symmetry of shoulder motion.

1. Introduction

Subacromial pain syndrome (SAPS), also known as subacromial impingement, has a high prevalence in the general population (van der Windt et al., 1995; Dierckx et al., 2014). SAPS is characterized by shoulder pain, decreased muscle strength and impaired active shoulder function (Harrison and Flatow, 2011). The etiology of SAPS is debated, as multiple factors are advocated to contribute to its pathophysiology (Ludewig and Reynolds, 2009; de Witte et al., 2013; Kibler et al., 2013). These factors include the compression of anatomic structures within the subacromial space, overuse of glenohumeral muscles, dynamic glenohumeral translation by rotator cuff degeneration and scapular dyskinesis (de Witte et al., 2011; Harrison and Flatow, 2011; de Witte et al., 2013).

Quantitative assessment of scapular kinematics with three-dimensional (3D) electromagnetic tracking revealed scapular dyskinesis in patients with SAPS (Lukasiewicz et al., 1999; Ludewig and

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Cook, 2000; McClure et al., 2006). Scapular dyskinesis with increased internal rotation (i.e. protraction), decreased upward rotation (i.e. lateral rotation) and posterior tilt are suggested to reduce the subacromial space and to impinge subacromial tissues (Warner et al., 1992; Solem-Bertoft et al., 1993; Lukasiewicz et al., 1999; Ludewig and Cook, 2000; Endo et al., 2001; Graichen et al., 2001; Hebert et al., 2002). The association between altered scapular kinematics and SAPS led to the application of several treatments targeted at scapular movements (McClure et al., 2004; Camargo et al., 2009; Holmgren et al., 2012). Unfortunately, success rates of treatment vary from 24% to 69% (McClure et al., 2004; Holmgren et al., 2012). The latter underlines the still unclear relation between subacromial shoulder pain and scapular dyskinesis. If scapula dyskinesis, clinically referred to as asymmetry in scapular motion (Uhl et al., 2009), is the consequence of pain, scapular kinematics may return to symmetrical shoulder kinematics after infiltration of subacromial anaesthetics. Ettinger et al. studied the effect of subacromial anesthetics in shoulders with SAPS and compared kinematics in SAPS with kinematics in healthy controls. However, it remains unknown whether kinematics are more symmetrical after subacromial infiltration with anaesthetics (Ettinger et al., 2014).

The purpose of this study is to investigate the effect of subacromial anaesthetics on scapular kinematics in patients with SAPS. We hypothesize that scapular kinematics are asymmetric with more internal rotation, less upward rotation and less posterior tilt in the affected shoulder. Second, we hypothesize that scapular kinematics restore to symmetrical kinematics after infiltration of subacromial anaesthetics in the shoulder with subacromial pain.

2. Materials and methods

Between April 2010 and December 2012 all consecutive patients with the clinical diagnosis SAPS referred to the outpatient clinics of three participating hospitals (Leiden University Medical Center, Medical Center Haaglanden and Rijnland Hospital) were evaluated for inclusion in this cross-sectional biomechanical cohort study (Trial register no. NTR2283). The study protocol has been previously published (de Witte et al., 2011). Eligible patients were invited at the (Leiden University medical Centre, Leiden, the Netherlands) for shoulder evaluation by various experimental set-ups including 3D electromagnetic motion analysis. The institutional medical ethical review board approved this study (P09.227) and written informed consent was obtained for every included patient.

2.1. Participants

Inclusion of patients was based on clinical symptoms, shoulder X-ray's and MR arthrography. Patients, aged 35–60 years, with unilateral shoulder complaints for at least 3 months due to SAPS were eligible for inclusion. SAPS was considered when a positive Hawkins test, a positive Neer impingement test and at least one of the following symptoms were present: pain during daily life activities with arm abduction, extension, and/or internal rotation, pain at night or incapable of lying on the shoulder, painful arc, diffuse pain at palpation of the greater tuberosity, scapular dyskinesis, and positive full or empty can test or positive Yocum test (de Witte et al., 2011).

Exclusion criteria were: insufficient language skills, no informed consent, any form of inflammatory arthritis of the shoulder, clinical signs of glenohumeral or acromioclavicular osteoarthritis, history of shoulder surgery, fracture or dislocation of the affected shoulder, cervical radiculopathy, glenohumeral instability, decreased passive function (e.g. frozen shoulder), and presence of a pacemaker or other electronic implants. Additionally, patients were excluded in case of an alternative diagnosis on radiographs or magnetic resonance (MR) arthrography like: calcific tendinitis, full-thickness rotator cuff tear, partial articular supraspinatus tendon avulsion (PASTA lesion), labrum or ligament pathology, pulley lesion, biceps tendinopathy, os acromiale, tumour, cartilage lesion, and a bony cyst. All MR arthrographies were evaluated by an independent radiologist.

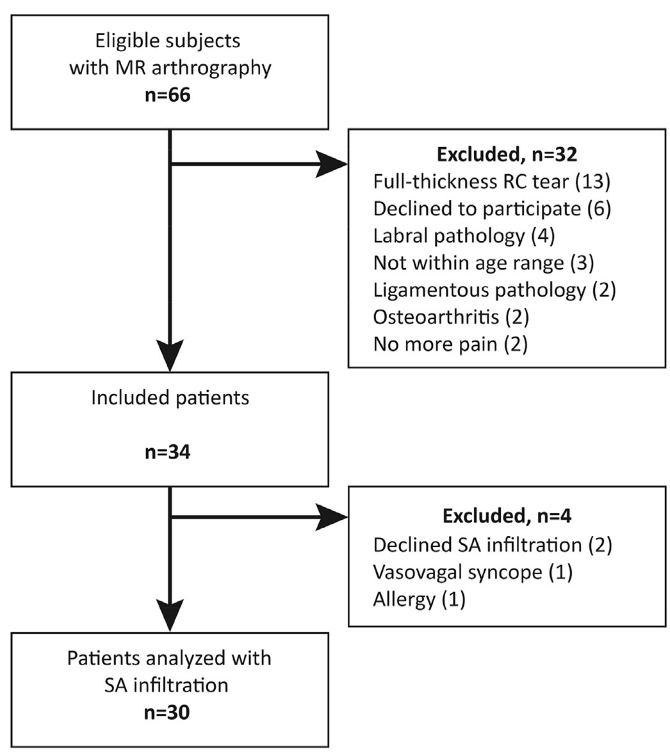
Initially, 66 patients were clinically diagnosed with SAPS and were subsequently scanned with MR arthrography. From these 66 patients, 32 subjects (Fig. 1) were excluded due to an alternative diagnosis on the MR arthrography (32%) or other exclusion criteria (17%), resulting in a total of 34 included patients with SAPS.

2.2. Measurement set-up

Three-dimensional motion was measured using the Flock of Birds electromagnetic tracking system (Ascension Technology Inc., Milton, Vermont, USA). The measurement set-up consisted of an extended range transmitter and six sensors to quantity bilateral shoulder motion in six degrees of freedom. The measurement method and analysis were previously described and validated (Milne et al., 1996; de Groot, 1997; Meskers et al., 1998a,b, 1999; Karduna et al., 2001).

Patients were seated in a standardized measurement set-up. Five wired receivers were attached using either adhesive tape (thorax and bilateral scapulae) or Velcro straps (bilateral distal humeral). The thorax sensor was adhered just above the xyphoid process and the scapular sensors were adhered on the flat cranial surface of the acromion. The humeral sensors were secured at the posterior flat surface of the distal upper arm. Additionally, one sensor was attached to a stylus to digitize bony landmarks.

The global and local Cartesian coordinate systems were described in accordance to the recommended ISB protocol (Wu et al., 2005). Twenty-four bony landmarks were identified by palpation and were digitized using a stylus to determine a local



(n, number; MR, magnetic resonance; RC, rotator cuff; SA, subacromial)

Fig. 1. Flow-chart.

coordinate system of the bony rigid bodies and its spatial orientation (de Groot, 1997; Meskers et al., 1999). We used the angulus acromialis for the local coordinate system of the scapula to limit data dispersion and potential gimbal lock in overhead positions (de Groot, 1997). The glenohumeral rotation centre was estimated by a least square method in a linear regression model (Meskers et al., 1998a; Veeger, 2000). Positions and orientations of the sensors were recorded at a sampling rate of approximately 30 Hz.

Patients were instructed to bilaterally complete four unconstrained tasks twice to their maximal range of shoulder motion and by keeping the arm in the appropriate plane: (1) elevation in the frontal plane, i.e. referred to as abduction; (2) forward elevation in a parasagittal plane, i.e. referred to as forward flexion; (3) backward elevation in a parasagittal plane, i.e. referred to as extension and (4) external rotation. External rotation was performed in 90° of forward flexion and with the elbow 90° flexed. Patients were instructed to complete each movement in approximately 10 s with a constant velocity. Forward flexion, extension and external rotation were only used to determine the maximal range of motion. For abduction we further investigated the scapulothoracic motion.

2.3. Data processing

Positions were expressed in the right-handed local coordinate system of the thorax around perpendicular anterior (X_t), superior (Y_t) and lateral (Z_t) directed axes. Rotations were described using Euler or Cardan angle sequences as recommended (Wu et al., 2005). Scapulo-thoracic motion ($Y_t - x'_s - z''_s$) was described as internal rotation (positive rotation around thoracic Y_t-axis and also known as protraction), upward rotation (negative rotation around scapular x'_s-axis and also known as lateral rotation) and posterior tilt (positive rotation around scapular z''_s-axis). Scapular internal rotation, upward rotation and posterior tilt are here presented as positive motions. Humero-thoracic motion ($Y_t - x'_h - y''_h$) was described as plane of elevation (rotation around thoracic Y_t-axis), elevation (negative rotation around humeral x'_h-axis) and external rotation (negative rotation around humeral y''_h-axis). Humeral elevation and external rotation are presented as positive motions.

Data were analysed by custom made software in MATLAB 2013b (The MathWorks Inc., Natick, Massachusetts, USA). The scapular positions were calculated for every participant and for every 10° increment from 10° to 120° of abduction (eleven intervals). Scapular motion at higher than 120° elevation angles were not included in the analysis since skin movement artefacts at high humeral elevation angles introduce measurement inaccuracies (de Groot, 1997; Karduna et al., 2001; Meskers et al., 2007).

2.4. Clinical assessment of pain and function

Patients reported their daily experienced pain at rest and movement during activities of daily living on a 100 mm Visual Analogue Scale (VAS, 0 mm, no pain; 100 mm, severe pain). VAS for pain during elevation of the arm was not obtained in one participant. Furthermore we obtained the Constant Score before the infiltration of subacromial anesthetics (Constant et al., 2008). Patients repeated shoulder abduction approximately 10–20 min after the infiltration of 5 ml of 1.0% lidocaine via a 21 gauge needle in the subacromial space using a posterior approach (Marder et al., 2012). Following subacromial anaesthetics, all patients verbally reported reduced pain. Sensors were left in place during administration of anaesthetics and bony landmarks were not re-measured after infiltration.

2.5. Statistical analysis

Categorical data were described with numbers and percentages. Non-parametric data were described with medians and interquartile ranges (IQR). Normally distributed data were described with means and 95%-confidence intervals (95% CI). Studying the effect of subacromial infiltration was a secondary goal of our SAPS cohort study (de Witte et al., 2011). We conducted an interim analysis on all 34 consecutive patients included between April 2010 and December 2012, after which we suspended further kinematic experiments after subacromial infiltration.

To compare maximal shoulder movements a paired Student's t-test was used. Scapular kinematics were analysed for abduction by using a linear mixed model analysis (Verbeke, 2009). Since two movements within a single subject are related, we calculated the paired difference between: (1) unaffected versus affected shoulder before the application of anaesthetics, and (2) affected shoulder before versus after the infiltration of anaesthetics. The dependent variable was the paired difference in scapulothoracic motion (i.e. scapular internal rotation, upward rotation and tilt). Abduction intervals were the repeated factor. Since errors between repeated measurements (i.e. intervals) are related (i.e. covariance), covariance at different elevation angles was modelled using an autoregressive structure of order one with unequal variances (Verbeke, 2009). The abduction interval was our independent variable of interest. Small variance in humeral rotations may exist when repeating abduction, thought differences in plane of humeral elevation or humeral axial rotation did not change the study outcome and were therefore not incorporated in our final models. The relation between scapular kinematics and VAS for pain during shoulder movement was investigated by forced entry linear regression analysis for each rotation. Statistical analysis was performed using IBM SPSS statistics for Windows version 20.0 (IBM Corp, 2011; Armonk, New York, USA). A two sided p-value of <0.05 was considered statistical significant.

3. Results

Thirty-four patients with SAPS were analysed in this study (Table 1). The effect of subacromial infiltration was analysed in thirty patients as a consequence of: vasovagal syncope ($n = 1$), known allergy to lidocaine ($n = 1$) and patients' refusal to undergo infiltration ($n = 2$).

Maximal abduction (146 ± 15.4° versus 136 ± 20.0°, $p = 0.002$) and forward flexion (145 ± 13.4° versus 138 ± 12.3°, $p = 0.004$)

Table 1
Baseline characteristics.

Characteristics (n = 34)		
Age, yrs	(mean, SD)	50 ± 6.2
Weight, kg		80 ± 14.4
Length, cm		173 ± 11.8
Female	(n, %)	20 (58.8)
Left side affected		20 (58.8)
Right side dominance		29 (85.3)
Spontaneous onset of symptoms		28 (82.4)
Pain at night		29 (85.3)
Pain during daily life activities		29 (85.3)
Tendinosis supraspinatus		20 (58.8)
Effusion bursa		14 (41.2)
VAS at rest, mm	(median, IQR)	12 (2.0–25.3)
VAS during motion, mm		40 (17.5–58.0)
CS, points		73 (69.0–80.3)

(n, number; yrs, years; SD, standard deviation; kg, kilograms; cm, centimeter; VAS, visual analogue scale; mm, millimeter; IQR, Interquartile range; CS, Constant Score).

were higher for the unaffected shoulder compared with the affected shoulder. Extension (59 ± 10.8° versus 55 ± 12.6°, p = 0.059) and external rotation in 90° of forward flexion (85 ± 10.9° versus 81 ± 13.2°, p = 0.075) were not significantly higher in unaffected shoulders.

Following subacromial anaesthetics, only maximal abduction improved in the affected shoulder from 136 ± 20.0° to 141 ± 16.0° (p = 0.046).

3.1. Scapular kinematics in unaffected versus affected shoulders

With humeral abduction, we observed scapular external rotation (Fig. 2A), upward rotation (Fig. 2B) and posterior tilt (Fig. 2C) in both shoulders. The difference in scapular internal rotation was significantly dissimilar (p = 0.020) at various abduction intervals (Table 2). No differences could be detected at the lower arm positions (i.e. <80° arm abduction), indicating no initial differences. At of 80° of arm abduction, internal rotation was higher in the affected shoulders. For example, scapular internal rotation was 5° (95% CI 0.4–9.7, p = 0.034) higher in the affected shoulder at 110–120°.

Upward rotation and scapular posterior tilt were not statistically different between affected and unaffected shoulders.

3.2. Effect of subacromial anaesthetics on scapular kinematics

Following subacromial anaesthetics, the difference in internal rotation was dissimilar (p < 0.001) at various intervals of abduction (Table 2). The difference in posterior tilt also significantly varied (p = 0.013) over the abduction intervals. The increase in scapular internal rotation and decrease in posterior tilt was only apparent at higher abduction angles. For example, the affected shoulder was 2° (95% CI 0.5–3.9, p = 0.045) more internally rotated, and posterior tilt was 3° (95% CI 1.5–5.0, p = 0.001) decreased after subacromial infiltration at 110–120° of abduction (Table 2). Upward rotation was not affected by subacromial infiltration (p = 0.445). Internal rotation, upward rotation and posterior tilt were not statistically different between the two abduction movements in the unaffected shoulder.

3.3. Association between scapular kinematics and VAS for pain

Median VAS for pain at rest was 12 mm (IQR 2–25 mm) and movement during activities of daily living 40 mm (IQR 18–58 mm). Reduced upward rotation at the initial abduction interval was significantly associated with a higher VAS for pain (2°/mm VAS) in the affected shoulder before infiltration was applied (Table 3).

4. Discussion

Scapular kinematics were studied before and after infiltration of the subacromial space with anaesthetics in the affected shoulder. There was more scapular internal rotation at higher abduction angles in the affected shoulder compared with the contralateral unaffected shoulder. Following subacromial anaesthetics, scapular kinematics did not restore to symmetric scapular kinematics. We observed increased asymmetry in scapular kinematics with more internal rotation and less posterior tilt after infiltration.

Our findings on the effect of subacromial anaesthetics largely agree with the results of a previous study (Ettinger et al., 2014). Following the infiltration of subacromial anaesthetics, the authors reported a comparable reduction in posterior tilt at greater elevation angles in shoulders of patients (Ettinger et al., 2014). Ettinger et al. did not observe an effect of infiltration on internal rotation, which is in contrast to our findings (Ettinger et al., 2014). In contrast to the healthy controls used in the study of Ettinger et al., we investigated the effect of subacromial anaesthetics compared to the

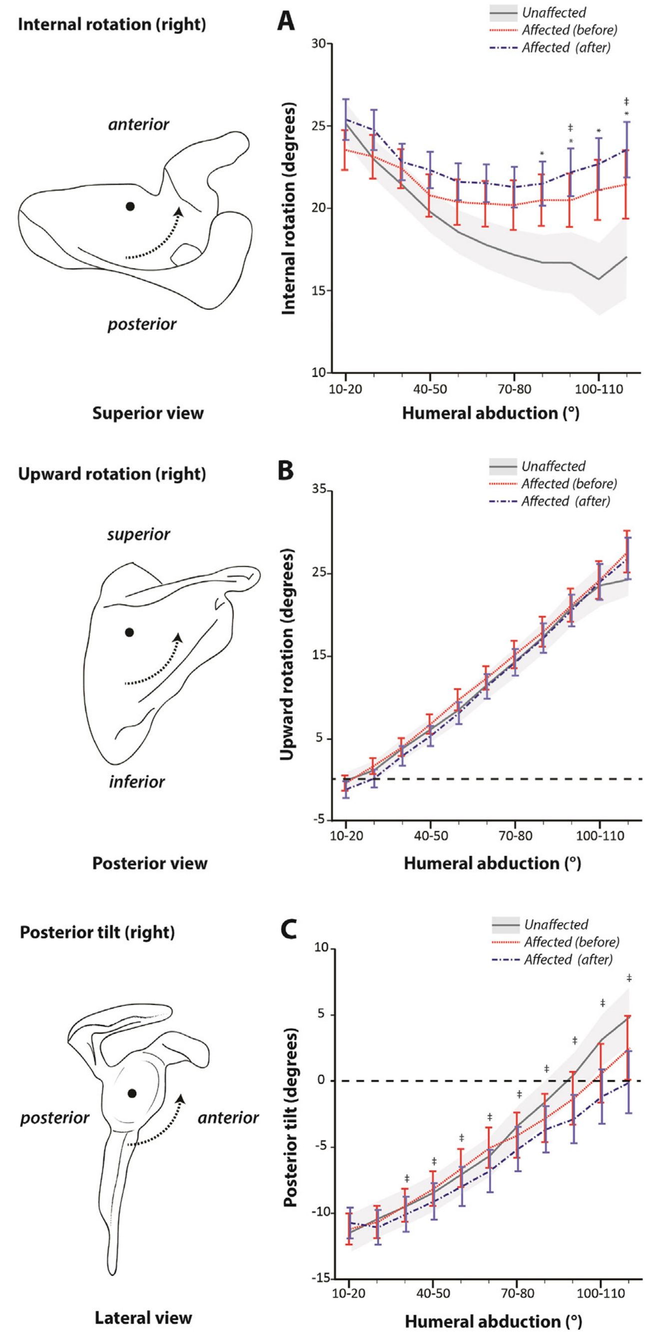


Fig. 2. Scapular kinematics as function of abduction. Data are presented as means and bars represent one standard error. The data were analysed by *pairwise* linear mixed model analysis and therefore the illustrated bars may not directly reflect significant effects. Statistical significant differences (at p < 0.05) are indicated by: (*) unaffected versus affected shoulder (before); (‡) affected before versus after application of analgesics.

contralateral asymptomatic shoulder, because scapular dyskinesis was previously defined as asymmetrical scapular kinematics. Participants from both studies elevated their arm in a different plane (i.e. elevation in the scapular plane versus frontal plane), which makes a direct comparison less appropriate as scapular kinematics in the scapular plane are different from kinematics in the frontal plane (Ludewig et al., 2009). Although SAPS is frequently identified after physical examination, physical examinations lack accuracy to discriminate SAPS from a full-thickness RC tear and clinicians disagree on diagnostic criteria for SAPS (Park et al., 2005; de Witte

Table 2
Mixed model analysis for scapular motion.

	Unaffected − affected (before)				Affected (before) − affected (after)			
	Model	Mean change	95% CI	p-value	Model	Mean change	95% CI	p-value
Internal rotation								
10–20	**0.020***	0	−2.7–3.6	0.779	**<0.001***	−1	−2.8–0.2	0.085
20–30		−0	−3.1–2.9	0.937		−2	−3.1–0.1	0.072
30–40		−1	−3.7–1.9	0.506		−0	−2.0–1.5	0.797
40–50		−1	−3.9–2.0	0.509		−1	−2.9–0.1	0.074
50–60		−2	−4.7–1.2	0.230		−1	−2.5–0.5	0.175
60–70		−3	−5.5–0.6	0.107		−1	−2.2–0.3	0.114
70–80		−3	−6.2–0.2	0.065		−1	−2.1–0.3	0.148
80–90		−4	−7.3–−0.4	**0.028***		−1	−2.3–0.5	0.205
90–100		−4	−7.9–−0.2	**0.041***		−2	−3.2–−0.3	**0.017***
100–110		−5	−8.9–−0.4	**0.034***		−2	−3.1–0.0	0.055
110–120		−5	−9.7–−0.4	**0.034***		−2	−3.9–−0.5	**0.045***
Upward rotation								
10–20	0.898	−0	−2.9–2.8	0.781	0.445	1	−0.3–1.7	0.181
20–30		−1	−3.5–2.5	0.891		1	0.1–2.4	**0.031***
30–40		−0	−3.3–3.1	0.865		1	−0.1–2.1	0.070
40–50		−1	−3.8–2.7	0.673		1	−0.2–2.7	0.077
50–60		−1	−4.5–2.2	0.581		1	−0.1–2.8	0.065
60–70		−1	−4.0–2.4	0.603		1	−0.8–2.3	0.334
70–80		−1	−4.2–2.4	0.499		1	−1.0–2.4	0.426
80–90		−1	−3.9– 2.6	0.727		0	−1.5–2.4	0.653
90–100		−0	−3.9–3.3	0.952		0	−1.8–2.1	0.869
100–110		−0	−4.0–3.5	0.752		−0	−2.5–2.2	0.885
110–120		−1	−4.4–3.3	0.964		−0	−3.0–2.2	0.761
Posterior tilt								
10–20	0.248	0	−1.8–2.7	0.692	**0.013***	0	−0.9–1.5	0.559
20–30		0	−2.2–2.3	0.982		1	−0.4–2.0	0.171
30–40		−0	−2.4–1.8	0.778		1	0.1–2.4	**0.040***
40–50		−1	−2.7–1.7	0.655		1	0.2–2.6	**0.020***
50–60		−1	−3.0–1.8	0.608		2	0.5–2.9	**0.009***
60–70		−1	−3.2–2.0	0.646		2	0.6–3.2	**0.005***
70–80		0	−2.8–2.9	0.954		2	0.4–3.2	**0.013***
80–90		1	−2.6–3.7	0.724		2	0.3–3.0	**0.022***
90–100		1	−2.5–4.6	0.545		2	0.3–3.5	**0.022***
100–110		1	−2.6–5.4	0.486		2	0.6–4.0	**0.010***
110–120		2	−2.6–6.2	0.413		3	1.5–5.0	**0.001***

Mean differences between the unaffected and affected shoulder (before and after subacromial infiltration) at the lowest (10–20°) and highest (110–120°) abduction interval. Differences appeared at higher degrees of humeral abduction and no offset differences were observed. * indicates a statistical significant difference at $p < 0.05$. (95% CI, 95% confidence interval; vs, versus).

Table 3
Association between pain and scapular kinematics in the affected shoulder.

Abduction	R	Mean change	95% CI	p-value	
10–20°	0.036	Internal rotation	−0	−1.7–1.4	0.852
	0.456	Upward rotation	−2	−3.8–0.5	**0.013***
	0.363	Posterior tilt	−1	−2.8–0.0	0.053

Results of forced entry linear regression analysis for the prediction of VAS for pain during elevation of the arm in the affected shoulder at the lowest interval (10–20°). The change in scapular rotation on the VAS pain scale is reported in °/mm. * indicates a statistical significant difference at $p < 0.05$. (R, correlation coefficient; 95% CI, 95% confidence interval).

et al., 2013). Dissimilar inclusion criteria may result in different samples of patients with SAPS and may influence study outcomes. In this study patients were included after excluding patients with a rotator cuff tear or other intra-articular pathology found on MR arthrography. Additional imaging improved homogeneity of the study population. Inclusion of rotator cuff tears might have biased our study due to the pathologic upward rotation observed in patients with a rotator cuff tear (Scibek et al., 2008; Kolk et al., 2015). Lidocaine will diffuse to the glenohumeral joint in patients with a rotator cuff tear, and therefore may obscure the effect of subacromial anaesthetics in patients with SAPS.

Contradicting results have been reported with respect to (pathologic) scapular kinematic patterns in patients with SAPS (Lukasiewicz et al., 1999; Ludewig and Cook, 2000; Endo et al., 2001; Hebert et al., 2002; McClure et al., 2006). In concordance with most literature, we found less posterior tilt in the affected shoulder (Lukasiewicz et al., 1999; Ludewig and Cook, 2000; Hebert et al., 2002; McClure et al., 2006; Ettinger et al., 2014). There is no consensus in literature on how internal rotation or upward rotation in patients with SAPS differs from kinematics in healthy shoulders (Lukasiewicz et al., 1999; Ludewig and Cook, 2000; Endo et al., 2001; McClure et al., 2006). Some authors demonstrated reduced upward rotation in SAPS (Ludewig and Cook, 2000; Endo et al., 2001), while others did not (Lukasiewicz et al., 1999) or even found increased upward rotation (McClure et al., 2006). Different selection criteria, measurement set-up or data processing (e.g. planes of elevation, bony landmarks, rotation sequences) may partially explain inconsistencies. Nevertheless, many authors postulate that increased internal rotation, reduced upward rotation and posterior tilt may result in a decline of the anterior subacromial space with subsequent painful compression of subacromial tissues (Solem-Bertoft et al., 1993; Lukasiewicz et al., 1999; Ludewig and Cook, 2000; Endo et al., 2001; Hebert et al., 2002). The possibility that an inverse relation, where subacromial pain creates asymmetry of scapular motion, should however not be ignored a priory.

Subacromial anaesthetics have the ability to reduce pain and pathologic antagonistic muscle activity of shoulder adductors when abducting the humerus (de Groot et al., 2006; Steenbrink et al., 2006). Subsequently, we hypothesised that pain results in scapular dyskinesis with a restoring effect of lidocaine on scapular dyskinesis. However, we did not find symmetrical scapular kinematics after subacromial anaesthesia, which does not support our hypothesis. Further, this finding may indicate that subacromial infiltration alone is not sufficient to restore scapular kinematics in patients with SAPS and might support the use of specific exercise strategies targeting scapular kinematics and scapular stabilization (Holmgren et al., 2012). However, the response on lidocaine infiltration must be interpreted with caution. Lidocaine infiltration may inhibit proprioceptive or other receptors within the shoulder, although no effect of subacromial anaesthetics on position sense was reported in participants without shoulder complaints (Zuckerman et al., 1999). Next, muscle activation might gradually change over time after infiltration, though it is currently unknown how motor output is exactly affected by a sudden relieve of pain (Struyf et al., 2015). Moreover, the infiltrated volume may increase subacromial pressure which may increase asymmetry of scapular motion found in our study.

This study has several methodological limitations. Although 3D electromagnetic motion analysis is a valid way to assess shoulder motion, the estimation of the glenohumeral rotation center and artefacts derived from displacement between skin and bone potentially introduce measurement variability (de Groot, 1997; Meskers et al., 1998a, 2007; Karduna et al., 2001). In addition, different velocities between repeated movements may have an effect on the outcome. Previous research demonstrated that asymptomatic rotator cuff tears are prevalent, especially in patients with contralateral shoulder complaints (Yamaguchi et al., 2006; Moosmayer et al., 2014). Asymptomatic pathology in the contralateral shoulder could limit the power to detect asymmetry in scapular motion. In addition, the effect of subacromial anaesthesia on pain may have been incomplete by the limited accuracy of the infiltration technique without ultrasound guidance (Marder et al., 2012). The effect of subacromial infiltration was not quantitatively assessed on a VAS for pain scale during shoulder movement, although verbal feedback was obtained. Incomplete anaesthesia will lead to an increase in variance within the dependent variable and thus a lower chance to detect an effect on kinematics. Finally, an healthy control group is warranted to evaluate whether observed effects of subacromial anesthetics in SAPS are exclusively attributed to the elimination of pain.

Future research may elucidate the definitions of pathologic scapular kinematics, evaluate the effect of subacromial anaesthetics in healthy controls and examine the natural course of scapular dyskinesis in patients with SAPS.

In conclusion, the affected shoulder in patients with SAPS had more scapular internal rotation compared with the contralateral unaffected shoulder. Less upward rotation and posterior tilt were associated with higher patient-reported pain. Scapular kinematics did not instantly restore towards symmetry of shoulder kinematics after the infiltration of subacromial anaesthetics. We even observed an increase in asymmetrical scapular motion after subacromial infiltration. These findings indicate that subacromial infiltration with lidocaine may not be an effective means for short-term restoration of symmetrical shoulder motion.

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Ethical committee approval

The institutional ethic review board of the Leiden University Medical Center approved the study (P09.227).

Conflict of interest

None declared

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