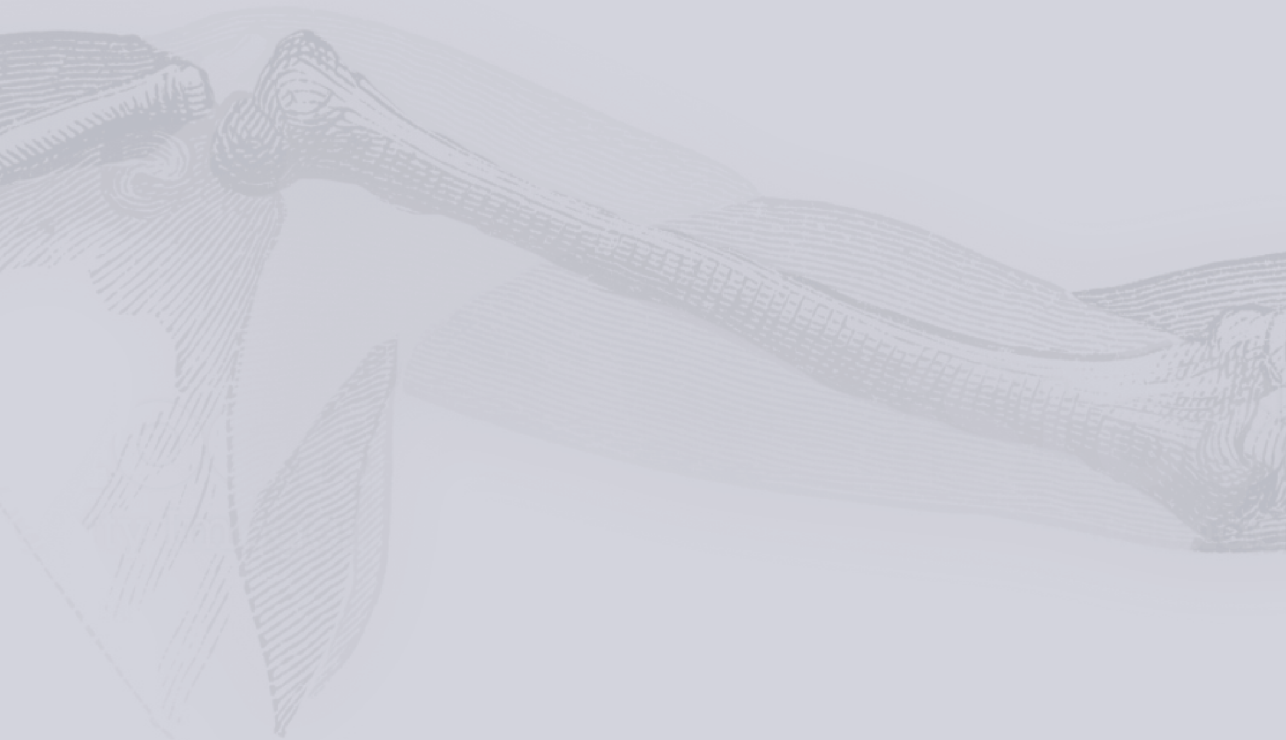
Functional implications of structural "anomalies" in shoulder pain

Kolk, A.



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

A. Kolk
JF. Henseler
PB. de Witte
E.R.A. van Arkel
C.P.J. Visser
J. Nagels
R.G.H.H. Nelissen
J.H. de Groot

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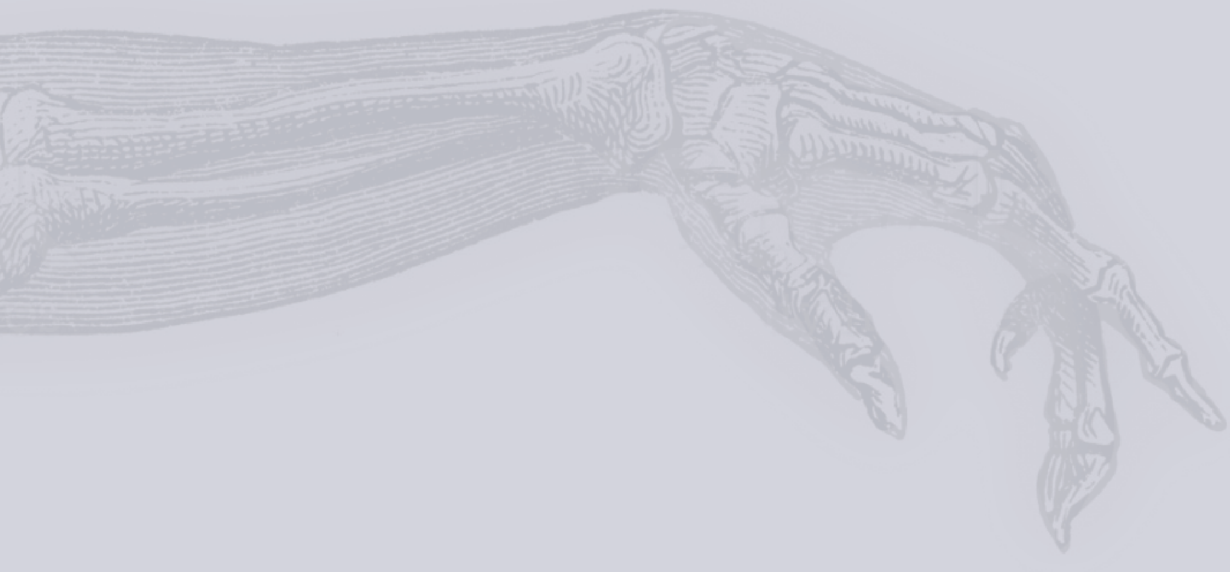

ABSTRACT

Background: Subacromial pain syndrome (SAPS) and scapular dyskinesis are closely associated, but the role of pain is unknown. We hypothesised that pain results in asymmetrical scapular kinematics, and we expected more symmetrical kinematics after infiltration of subacromial anaesthetics. The aim of this study was to investigate the effect of subacromial anaesthetics on scapular kinematics in patients with SAPS.

Methods: In this observational cohort study, we evaluated shoulder kinematics in 34 patients clinically and radiological (magnetic resonance arthrography) identified with unilateral SAPS using three-dimensional electromagnetic motion analysis (Flock of Birds). Scapular internal rotation, lateral 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° (95% confidence interval 0.4° – 9.7°, P = 0.034) more 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% confidence interval 0.5° – 3.9°, P = 0.045) and posterior tilt decreased (3°, 95% confidence interval 1.5° – 5.0°, P = 0.001) at 110-120° of abduction. Less scapular lateral 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 towards symmetrical scapular motion. These findings suggest that subacromial anaesthesia is not an effective means to instantly restore symmetry of shoulder motion.

INTRODUCTION

Subacromial pain syndrome (SAPS), also known as subacromial impingement, is prevalent in patients with shoulder complaints.[7, 36] SAPS is characterised by shoulder pain, decreased muscle strength and impaired active shoulder function.[11] The aetiology of SAPS is debated**,** as multiple factors are advocated to contribute to its pathophysiology.[5, 15, 19] 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.[5, 6, 11]

Quantitative assessment of scapular kinematics with three-dimensional (3D) electromagnetic tracking revealed scapular dyskinesis in patients with SAPS.[17, 20, 23] Scapular dyskinesis with increased internal rotation (i.e. protraction), decreased lateral rotation (i.e. upward rotation) and posterior tilt are suggested to reduce the subacromial space and to impinge subacromial tissues.[8, 10, 12, 17, 20, 32, 39] The association between altered scapular kinematics and SAPS led to the application of several programmes targeted at scapular movements.[1, 13, 22] Unfortunately, success rates of treatment vary from 24%-69%.[13, 22] 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 is the consequence of pain, scapular kinematics may return to symmetrical shoulder kinematics after infiltration of subacromial anaesthetics.[35] Ettinger et al. studied the effect of subacromial anaesthetics in shoulders with SAPS related this kinematics to healthy controls, but it remains unknown whether kinematics are more symmetrical after subacromial infiltration with anaesthetics.[9]

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

MATERIALS AND METHODS

Between April 2010 and December 2012 all consecutive patients referred to the outpatient clinics of three participating hospitals (Leiden University Medical Centre, Medical Centre 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.[6] 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.

Participants

Inclusion of patients was based on clinical symptoms, shoulder X-ray's and magnetic resonance arthrography (MRA). 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.[6]

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 MRA 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 MRA were evaluated by an independent radiologist.

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

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.[3, 14, 24, 26-28]

Patients were seated in a standardized measurement set-up. Five wired receivers were attached using either adhesive tape (thorax and bilateral scapulae) or straps with hook-and-loop fastener (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.

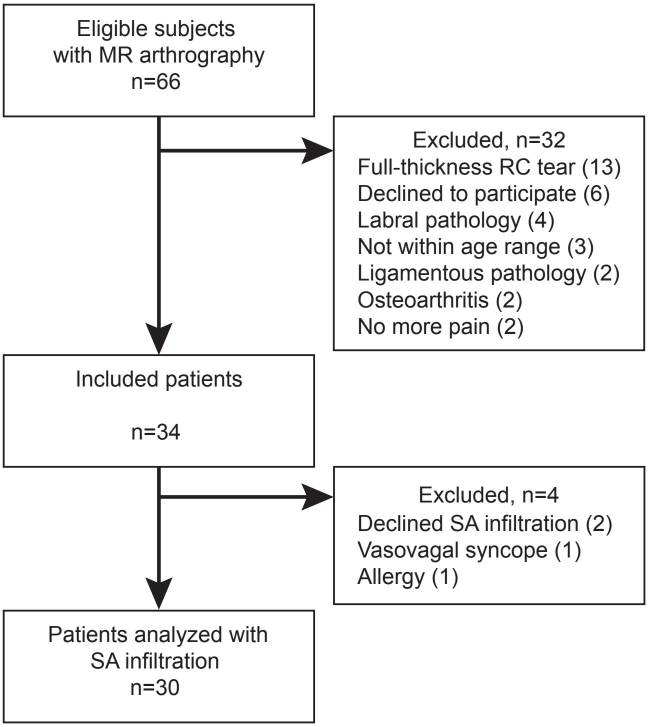

Figure 1. Flow-chart. Abbreviations: n, number; MR, magnetic resonance; RC, rotator cuff; SA, subacromial.

The global and local Cartesian coordinate systems were described in accordance to the recommended ISB protocol.[40] Twenty-four bony landmarks were identified by palpation and were digitized using a stylus to determine a local coordinate system of the bony rigid bodies and its spatial orientation.[3, 24].We used the angulus acromialis for the local coordinate system of the scapula to limit data dispersion and potential gimbal lock in overhead positions.[3] The glenohumeral rotation centre was estimated by a least square method in a linear regression model.[26, 37] Positions and orientations of the sensors were recorded at a sampling rate of approximately 30Hz.

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 90^0 of forward flexion and with the elbow 90^0 flexed. Patients were instructed to complete each movement in approximately 10 seconds 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.

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.[40] 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), lateral rotation (negative rotation around scapular x_s'-axis and also known as upward rotation) and posterior tilt (positive rotation around scapular z_s"-axis). Scapular internal rotation, lateral 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 release, The MathWorks Inc., Natick, Massachusetts, USA). The scapular positions were calculated for every participant and for every 10° increment from 10°-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.[3, 14, 25]

Clinical assessment of pain and function

Patients reported their daily experienced pain at rest and movement during activities of daily living on a 100mm Visual Analogue Scale (VAS, 0mm, no pain; 100mm, 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 anaesthetics.[2] Patients repeated shoulder abduction approximately 10-20 minutes after the infiltration of 5 ml of 1.0% lidocaine via a 21 gauge needle in the subacromial space using a posterior approach.[21] Following subacromial anaesthetics, all patients verbally reported reduced pain. Sensors were left in place during administration of anaesthetics and bony landmarks were not remeasured after infiltration.

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 (CI). Studying the effect of subacromial infiltration was a secondary goal of our SAPS cohort study.[6] 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.[38] 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, lateral 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.[38] 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 analyses were 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 statistically significant.

RESULTS

Thirty-four patients with SAPS were analysed in this study (Table 1). The effect of subacromial infiltration was analysed in 30 patients, because 4 patients were excluded: 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°; mean difference 9°, 95% CI 3.9° – 15.0°, P = 0.002) and forward flexion (145° ± 13.4° versus 138° ± 12.3°; mean difference 6°; 95% CI 2.2° – 10.7°, P = 0.004) were higher for the unaffected shoulder compared with the affected shoulder. Extension (59° ± 10.8° versus 55° ± 12.6°; mean difference 4°; 95% CI -0.2° – 7.4°, P = 0.059) and external rotation in 90^0 of forward flexion (85° ± 10.9° versus 81° ± 13.2°; mean difference 4°; 95% CI -0.4° – 8.5°, P = 0.075) were not significantly higher in the unaffected shoulders.

Following subacromial anaesthetics, only maximal abduction improved in the affected shoulder from 136° ± 20.0° to 141° ± 16.0° (mean difference 5°; 95% CI, 0.1° – 9.8°, P = 0.046).

Table 1. Baseline characteristics

N. of patients	34	
Age, mean ± SD, yrs	50 ± 6.2	
Weight, mean ± SD, kg	80 ± 14.4	
Length, mean ± SD, cm	173 ± 11.8	
Female, n (%)	20 (58.8)	
Left side affected, n (%)	20 (58.8)	
Right side dominance, n (%)	29 (85.3)	
Spontaneous onset of symptoms, n (%)	28 (82.4)	
Pain at night, n (%)	29 (85.3)	
Pain during daily life activities, n (%)	29 (85.3)	
Tendinosis supraspinatus, n (%)	20 (58.8)	
Effusion bursa, n (%)	14 (41.2)	
VAS at rest, median 25th and 75th percentile, mm	12	2.0-25.3
VAS during motion, median 25th and 75th percentile, mm	40	17.5-58.0
CS, median 25th and 75th percentile, points	73	69.0-80.3

Abbreviations: n, number; yrs, years; SD, standard deviation; kg, kilograms; cm, centimetre; VAS, visual analogue scale; mm, millimetre; IQR, Interquartile range; CS, Constant Score.

Scapular kinematics in unaffected versus affected shoulders

With humeral abduction, we observed scapular external rotation (Figure 2A), lateral rotation (Figure 2B) and posterior tilt (Figure 2C). 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°.

Lateral rotation and scapular posterior tilt were comparable between the affected and unaffected shoulders.

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 3). 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 3). Lateral rotation was not affected by subacromial infiltration (P = 0.445). Internal rotation, lateral rotation and posterior tilt were not different between the two abduction movements in the unaffected shoulder.

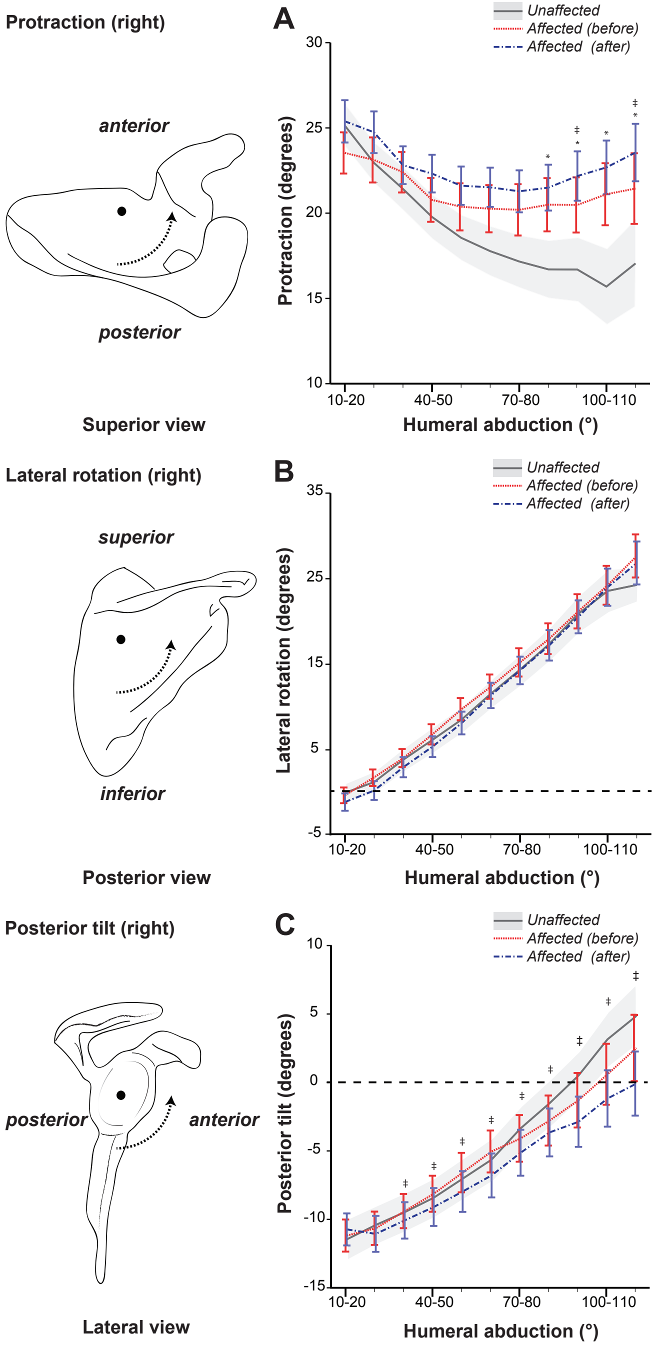

Figure 2. Scapular kinematics as function of abduction. Data are presented as means, and bars represent one standard error. The data were analysed with a *pair-wise* linear mixed model analysis.

* Statistically significant differences between the unaffected versus affected shoulder before infiltration.

‡ Statistically significant differences between the affected shoulder before infiltration versus after infiltration of analgesics.

Table 2. Mixed model analysis for scapular motion

Scapular internal rotation				
		Unaffected – affected (before infiltration)		
	Model	*Mean change*	*95% CI*	*P value*
10-20°	0.020*	0	-2.7 – 3.6	0.779
20-30°		-0	-3.1 – 2.9	0.937
30-40°		-1	-3.7 – 1.9	0.506
40-50°		-1	-3.9 – 2.0	0.509
50-60°		-2	-4.7 – 1.2	0.230
60-70°		-3	-5.5 – 0.6	0.107
70-80°		-3	-6.2 – 0.2	0.065
80-90°		-4	-7.3 – -0.4	0.028*
90-100°		-4	-7.9 – -0.2	0.041*
100-110°		-5	-8.9 – -0.4	0.034*
110-120°		-5	-9.7 – -0.4	0.034*
Scapular lateral rotation				
10-20°	0.898	-0	-2.9 – 2.8	0.781
20-30°		-1	-3.5 – 2.5	0.891
30-40°		-0	-3.3 – 3.1	0.865
40-50°		-1	-3.8 – 2.7	0.673
50-60°		-1	-4.5 – 2.2	0.581
60-70°		-1	-4.0 – 2.4	0.603
70-80°		-1	-4.2 – 2.4	0.499
80-90°		-1	-3.9– 2.6	0.727
90-100°		-0	-3.9 – 3.3	0.952
100-110°		-0	-4.0 – 3.5	0.752
110-120°		-1	-4.4 – 3.3	0.964
Scapular posterior tilt				
10-20°	0.248	0	-1.8 – 2.7	0.692
20-30°		0	-2.2 – 2.3	0.982
30-40°		-0	-2.4 – 1.8	0.778
40-50°		-1	-2.7 – 1.7	0.655
50-60°		-1	-3.0 – 1.8	0.608
60-70°		-1	-3.2 – 2.0	0.646
70-80°		0	-2.8 – 2.9	0.954
80-90°		1	-2.6 – 3.7	0.724
90-100°		1	-2.5 – 4.6	0.545
100-110°		1	-2.6 – 5.4	0.486
110-120°		2	-2.6 – 6.2	0.413

Mean differences between the unaffected and affected shoulder (before subacromial infiltration) at the lowest (10° to 20°) and highest (110° to 120°) abduction interval. Differences appeared at higher degrees of humeral abduction and no offset differences were observed. Abbreviations: CI, confidence interval.
* statistically significant.

Table 3. Mixed model analysis for scapular motion

Scapular internal rotation				
		Affected (before) – Affected (after infiltration)		
	Model	*Mean change*	*95% CI*	*P value*
10-20°	<0.001*	-1	-2.8 – 0.2	0.085
20-30°		-2	-3.1 – 0.1	0.072
30-40°		-0	-2.0 – 1.5	0.797
40-50°		-1	-2.9 – 0.1	0.074
50-60°		-1	-2.5 – 0.5	0.175
60-70°		-1	-2.2 – 0.3	0.114
70-80°		-1	-2.1 – 0.3	0.148
80-90°		-1	-2.3 – 0.5	0.205
90-100°		-2	-3.2 – -0.3	0.017*
100-110°		-2	-3.1 – 0.0	0.055
110-120°		-2	-3.9 – -0.5	0.045*
Scapular lateral rotation				
10-20°	0.445	1	-0.3 – 1.7	0.181
20-30°		1	0.1 – 2.4	0.031*
30-40°		1	-0.1 – 2.1	0.070
40-50°		1	-0.2 – 2.7	0.077
50-60°		1	-0.1 – 2.8	0.065
60-70°		1	-0.8 – 2.3	0.334
70-80°		1	-1.0 – 2.4	0.426
80-90°		0	-1.5 – 2.4	0.653
90-100°		0	-1.8 – 2.1	0.869
100-110°		-0	-2.5 – 2.2	0.885
110-120°		-0	-3.0 – 2.2	0.761
Scapular posterior tilt				
10-20°	0.013*	0	-0.9 – 1.5	0.559
20-30°		1	-0.4 – 2.0	0.171
30-40°		1	0.1– 2.4	0.040*
40-50°		1	0.2 – 2.6	0.020*
50-60°		2	0.5 – 2.9	0.009*
60-70°		2	0.6 – 3.2	0.005*
70-80°		2	0.4 – 3.2	0.013*
80-90°		2	0.3 – 3.0	0.022*
90-100°		2	0.3 – 3.5	0.022*
100-110°		2	0.6 – 4.0	0.010*
110-120°		3	1.5 – 5.0	0.001*

Mean differences between the affected shoulder before versus after subacromial infiltration at the lowest (10° to 20°) and highest (110° to 120°) abduction interval. Differences appeared at higher degrees of humeral abduction and no offset differences were observed. Abbreviations: CI, confidence interval.

* statistically significant.

4

Association between scapular kinematics and VAS for pain

Median VAS for pain at rest was 12 mm (IQR 2 – 25mm) and movement during activities of daily living 40 mm (IQR 18 – 58mm). Reduced lateral 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 4).

Table 4. 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	Lateral 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. Abbreviations: R, correlation coefficient; CI, confidence interval.
* statistically significant.

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 and a further increase in internal rotation and a further decrease in posterior tilt was observed.

Our findings on the effect of subacromial anaesthetics largely agree with the results of a previous study.[9] Following the infiltration of subacromial anaesthetics, the authors reported a comparable reduction in posterior tilt at greater elevation angles in shoulders of patients.[9] Ettinger et al. did not observe an effect of infiltration on internal rotation, which is in contrast to our findings.[9] In contrast to the healthy controls used in the study of Ettinger et al., we investigated the effect of subacromial anaesthetics compared to the 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. Scapular kinematics in the scapular plane are different from kinematics in the frontal plane.[18] 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.[5, 30] 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 intraarticular pathology found on MRA. Additional imaging improved homogeneity of the study population. Inclusion of rotator cuff tears might have biased our study due to the pathologic lateral rotation observed in patients with a rotator cuff tear.[16, 31] 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.[8, 12, 17, 20, 23] In concordance with most literature, we found less posterior tilt in the affected shoulder.[9, 12, 17, 20, 23] There is no consensus in literature on how internal rotation or lateral rotation in patients with SAPS differs from kinematics in healthy shoulders.[8, 17, 20, 23] Some authors demonstrated reduced lateral rotation in SAPS, while others did not or even found increased lateral rotation.[8, 17, 20, 23] 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 lateral rotation and posterior tilt may result in a decline of the anterior subacromial space with subsequent painful compression of subacromial tissues.[8, 12, 17, 20, 32] 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.[4, 33] Subsequently, we hypothesised that pain results in scapular dyskinesis with a comparable 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.[13] 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.[42] 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.[34] 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 centre and artefacts derived from friction between skin and bone potentially introduce measurement variability.[3, 14, 25, 26] 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.[29, 41] 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.[21] 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 anaesthetics 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.

CONCLUSION

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

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