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Association between scapula bony morphology and snapping scapula syndrome

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Hypothesis and background: Scapular incongruity has been described as a contributing factor to the development of snapping scapula syndrome (SSS). The purpose of this retrospective case-control study was to determine the association between scapula bony morphology on magnetic resonance imaging (MRI) and the diagnosis of SSS.

Methods: Bony morphologies of the scapula were evaluated on MRI scans of 26 patients with SSS and 19 patients with non-SSS pathologies. The medial scapula corpus angle (MSCA) was measured on axial MRI sequences. Scapulae were categorized as straight, S shaped, or concave. Two independent observers performed the measurements. Interobserver and intraobserver agreements of MSCA measurements were determined with intraclass correlation coefficients.

Results: Axial scapula bony morphology identified 28 scapulae of the straight type, 14 S-shaped scapulae, and 5 concave scapulae. All 5 concave scapulae had confirmed SSS. Measurement of the MSCA showed excellent interobserver agreement of 0.80 (95% confidence interval [CI], 0.67 to 0.89) and intraobserver agreement of 0.70 (95% CI, 0.52 to 0.82). There were significant differences in the mean MSCAs between shoulders with SSS (14.4° ± 19.3°) and non-SSS shoulders (−3.3° ± 15.3°, $P = .001$). The odds ratio was 8.4 (95% CI, 2.2 to 31.8) for positive MSCA and SSS. The scapulothoracic distance was significantly decreased in the SSS group (14.9 ± 5.8 mm) compared with the non-SSS patients (24.0 ± 6.7 mm, $P < .001$).

Discussion and conclusion: Anterior angulation of the medial scapula in the axial plane was associated with SSS. Patients with a concave-shaped scapula and a positive MSCA have a 12-fold increased risk of SSS. The MSCA may prove helpful in determining the location and amount of scapular resection needed for patients with SSS.

Level of evidence: Level III, Diagnostic Study.

Keywords: Snapping scapula syndrome; partial scapulectomy; medial scapula corpus angle; scapula bony morphology

Snapping scapula syndrome (SSS) was originally described by Boinet.[2] Thickening of the superior scapula angle from post-traumatic changes, Luschka tubercle, osteochondroma, or subscapular elastofibroma may be factors for painful snapping scapula.[3,13,17,18] However, in many cases, the origin of SSS remains unclear.

This study received institutional review board approval.

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Variations of the scapula costal surface, such as inward bending of the medial scapula border reported in 2% to 6% of the scapulae,[1,4] have been described as contributing to SSS.[1,4] In addition, multiple clinical studies have reported pain relief after resection of the superior medial border of the scapula.[5,7,10,11,14,19] Currently, there are no evidence-based guidelines regarding the amount of scapular resection needed. Warth et al[19] suggested the removal of a 2-cm (superior-to-inferior) by 3-cm (medial-to-lateral) triangular section of bone. Mozes et al[12] defined incongruity of the thoracoscapular articulation as either a superomedial scapula angle of less than 142°, inward bending of the medial scapula border, or the presence of a rhinoceros horn–like deformity inferiorly. They found deformities in all snapping scapulae by 3-dimensional (3D) computed tomography (CT). These variations in scapula bony morphology may play a role in the development of SSS.

The purpose of this study was to determine whether there was an association between SSS and the scapular configuration on the axial images of magnetic resonance imaging (MRI) scans. We hypothesized that an angulation of the costal surface of the upper third of the medial scapula toward the thorax may lead to painful impingement and that such a bony morphology would be associated with SSS.

Methods

Study cohort

Twenty-six patients who underwent surgical treatment for painful scapular bursitis and/or crepitus between July 2009 and May 2013 by the senior author (P.J.M.) were identified from a surgical registry. A focused chart review of these patients was performed. Patients were included in the study if they had preoperative MRI scans that included the scapula. Patients were excluded if they had previous surgical intervention to the scapula region or were aged younger than 18 years or older than 70 years, as well as in the case of poor MRI quality such as less than 1.5-T MRI, oblique axial cuts, or image artifacts.

Group 1 consisted of all patients with SSS, including a total of 26 patients and a total of 26 scapulae. All SSS pathologies were determined from preoperative clinical evaluation after the patient presented with symptoms localized to the superomedial angle of the scapula. These symptoms consisted of pain in the scapula region that was exacerbated by moving the scapula and resulted in a palpable click. All patients in group 1 underwent bursectomy and/or resection of the superomedial angle by the senior author (P.J.M.) after failed conservative treatment. No patient had bilateral SSS pathology.

Group 2 consisted of 19 patients who underwent an MRI scan of the scapula without SSS pathologies. All MRI scans of the scapula performed with the same sequences as the SSS-pathology MRI scans between the years 2011 and 2013 were evaluated. Patients who underwent MRI for pathologies other than SSS were included. All non-SSS pathologies are listed in Table I. Two patients underwent bilateral MRI scans for non-SSS pathologies. Therefore, 19 patients and 21 scapulae were included in group 2.

Table I Pathologies in non–SSS pathology patient group (21 scapulae)

Pathology	No. of scapulae
Complex shoulder instability	5
Fibromyalgia	4
Massive rotator cuff tear	3
Scapular strain	2
Scapular winging	2
Hemangioma	1
Lesion of nervus suprascapularis	1
AVN of humeral head	1
Sternoclavicular instability	1
Myogenic thoracic outlet syndrome	1

AVN, avascular necrosis.

Adding groups 1 and 2, we identified 38 patients (39 scapulae) who underwent an MRI scan using a 3.0-T Siemens Magnetom Verico MRI scanner (Siemens Medical Solutions, Erlangen, Germany). All MRI scans were performed with the patient in the supine position. The arms were placed by the side if tolerated. In 7 patients (8 scapulae), MRI scans were performed at outside imaging centers using 1.5-T magnets. No information on the patient position was available for these patients.

Assessment of scapula configuration

Two blinded observers—one radiologist and one orthopaedic surgeon—reviewed all scapular MRI scans. The region of interest was the upper third of the medial scapula, where clinical symptoms are commonly localized. To focus on the same region of the scapula, we defined a standardized approach for selecting the image slices. The following MRI sequences were used for analysis: axial fat-suppressed (short tau inversion recovery) images and proton density (fast/turbo spin echo) images. The axial slices had a slice thickness of 3 mm with a 0.3-mm gap between slices. They were scrolled from superiorly to inferiorly. After the diffusely circumscribed spina scapula was passed, the corpus scapula including the medial border was sharply defined. Particularly at the cranial part of the scapula, the medial scapula border was not well circumscribed, which might be caused by some inward bending of the superomedial border or Luschka tubercle. The first image with sharp borders, which presented the first sharp image of the corpus scapula, was selected and documented independently by both observers (Fig. 1). Finally, both observers evaluated the scapula corpus bony morphology type after exclusion of the glenoid region and categorized it as straight, S shaped, or concave.

Measurement of medial scapula corpus angle

The medial scapula corpus angle (MSCA) was measured using the same image slice as described earlier. The angle of the costal surface of the medial scapula border was measured (Fig. 2). MSCAs were measured using Stryker OfficePACS Power 4.1 Express Edition (Stryker, Kalamazoo, MI, USA). An angulation toward the thorax was defined as a positive angle.

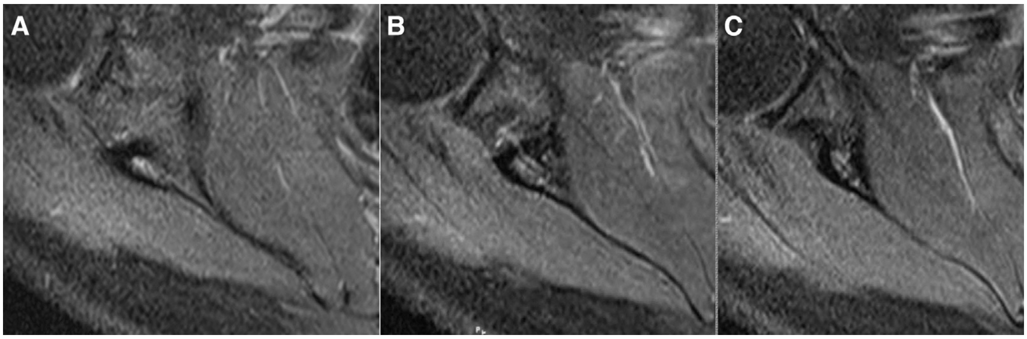

Figure 1 Sample of 3 adjacent axial magnetic resonance imaging slices, using proton density fast spin echo fat-suppressed sequence. Slice (**A**) is the slice immediately superior to the selected slice (**B**). Slice (**C**) is the slice immediately inferior to the selected slice (**B**). Whereas the scapula body of slice (**A**) offers a diffusely circumscribed scapula body, the selected slice (**B**) and the adjacent inferior slice (**C**) offer sharp defined borders. The image of interest of each patient was defined as the first sharp image of the corpus and medial border of the scapula after scrolling from superior to inferior and passing the diffusely circumscribed spina scapula region. The slice of interest (**B**) and the adjacent inferior slice (**C**) differ only marginally.

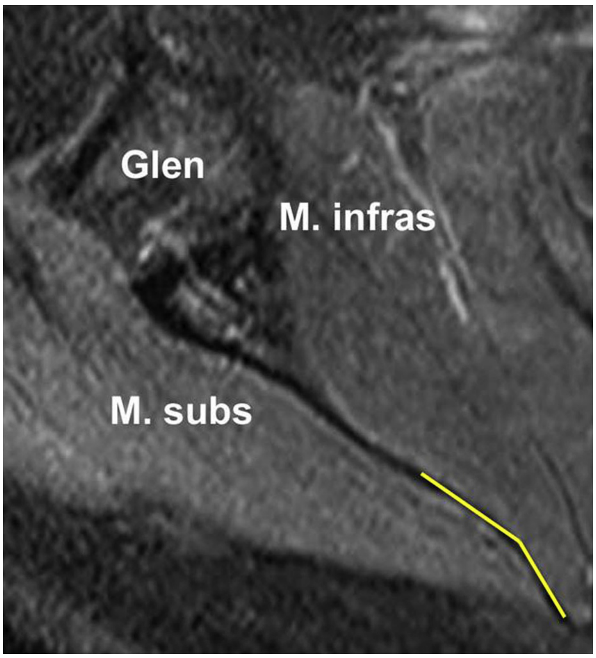

Figure 2 Sample of an axial magnetic resonance image, presented in Figure 1, showing the assessment of the medial scapula corpus angle (MSCA), measured along the costal surface of the medial scapula, which shows an obvious angulation (MSCA, −16°). *Glen*, glenoid; *M infras*, musculus infraspinatus; *M subs*, musculus subscapularis.

Measurement of scapulothoracic distance

By use of the same slice of interest, the minimum distance from the scapula corpus to the ribs was measured in millimeters.[1]

Measurement validity

The reproducibility of the MSCA measurement was examined with the interclass correlation coefficient for interobserver reliability (measurements made by 2 independent observers). Two independent observers measured the MSCA in all patients twice in random order. All measurements were performed between June and July 2013 with the observers blinded to the treatment the patient eventually underwent. The time interval between the repeated measurements was at least 2 weeks.

Statistical analysis

Statistical data analysis was performed with SPSS software, version 17.0 (SPSS, Chicago, IL, USA). Interobserver agreement was measured with the 2-way mixed single-measures interclass correlation coefficient. The MSCAs were normally distributed. Comparisons of the mean MSCA values and the study groups were performed with the independent *t* test. The Pearson correlation coefficient (R) was used for comparisons of the different scapula types and the MSCAs. The level of significance for statistical analysis was set at $P < .05$.

Results

Patient characteristics are listed in Table II. There were no statistically significant differences in patient characteristics between the groups. The mean age of the SSS group (group 1) was 36.8 years (range, 18 to 68 years) versus 41.6 years (range, 25 to 69 years; $P = .23$) in the non-SSS group (group 2). Similarly, there were no significant differences in gender distribution ($P = .59$) or the affected shoulder ($P = .10$) between the groups. Patients in the SSS group had a median duration of symptoms of 3.3 years (range, 0.5 to 10 years).

Scapula bony morphology

On the basis of our definition of the MRI slide of interest, both observers chose the same (19 of 47) or adjacent (20 of 47) slices of interest in 39 of 47 scapulae (83.0%). In the

Table II Patient collective

Patient No.	Scapula No.	Age, y	Sex	Side	Duration of symptoms, y	Group	Scapula type	MSCA, °	Dist to med border, mm	History of trauma
1	1	68	F	Left	3.0	SSS	I	−18	15.4	None
2	2	23	M	Left	1.5	SSS	III	−17	14.4	None
3	3	30	M	Left	1.0	SSS	I	14	16.5	Traffic accident
4	4	47	F	Right	2.5	SSS	II	−29	10.8	None
5	5	56	F	Left	5.0	SSS	I	2	12.0	Fall while riding a horse
6	6	23	F	Left	3.0	SSS	I	5	8.2	None
7	7	31	F	Right	0.5	SSS	I	10	8.8	Skiing collision
8	8	44	M	Right	1.0	SSS	II	10	20.0	None
9	9	31	M	Left	10	SSS	II	32	16.3	None
10	10	42	M	Left	6.0	SSS	III	−21	16.4	None
11	11	26	M	Right	5.0	SSS	I	−4	19.8	None
12	12	24	F	Left	2.0	SSS	I	18	19.0	None
13	13	60	M	Left	2.0	SSS	II	31	16.3	Fall from a ladder
14	14	41	M	Left	3.0	SSS	I	18	12.5	None
15	15	47	M	Right	0.5	SSS	II	12	9.0	None
16	16	46	M	Left	2.0	SSS	II	19	11.3	None
17	17	26	F	Right	10.0	SSS	III	20	16.0	None
18	18	23	F	Left	3.0	SSS	III	24	14.4	None
19	19	24	F	Right	7.0	SSS	I	13	4.8	None
20	20	18	M	Right	4.0	SSS	III	45	8.8	Traffic accident
21	21	51	F	Left	2.0	SSS	II	45	7.6	None
22	22	20	M	Left	2.0	SSS	I	13	12.6	None
23	23	38	M	Right	1.0	SSS	I	14	12.4	None
24	24	35	M	Left	4.0	SSS	I	40	10.5	None
25	25	23	F	Right	3.0	SSS	I	18	16.9	None
26	26	34	M	Left	3.0	SSS	I	41	15.0	None
27	27	29	F	Right	NE	Non-SSS	I	−10	12.8	NE
28	28	63	F	Right	NE	Non-SSS	I	−4	9.5	NE
29	29	54	M	Right	NE	Non-SSS	II	−14	14.7	NE
30	30	57	M	Right	NE	Non-SSS	I	−20	24.0	NE
31	31	46	M	Right	NE	Non-SSS	II	−11	16.8	NE
32	32	52	F	Right	NE	Non-SSS	I	−17	13.0	NE
33	33	43	F	Right	NE	Non-SSS	I	−3	15.0	NE
34	34	55	M	Right	NE	Non-SSS	I	−16	17.0	NE
35	35	29	M	Right	NE	Non-SSS	I	−14	11.3	NE
35	36	29	M	Left	NE	Non-SSS	I	−19	14.3	NE
36	37	40	F	Right	NE	Non-SSS	I	−26	8.1	NE
36	41	40	F	Left	NE	Non-SSS	I	−4	12.6	NE
37	38	31	M	Left	NE	Non-SSS	I	−4	13.8	NE
38	39	36	M	Right	NE	Non-SSS	I	4	15.0	NE
39	40	25	F	Left	NE	Non-SSS	I	14	16.8	NE
40	42	43	F	Right	NE	Non-SSS	I	7	12.3	NE
41	43	63	M	Left	NE	Non-SSS	I	13	21.6	NE
42	44	28	F	Left	NE	Non-SSS	I	28	20.3	NE
43	45	25	F	Left	NE	Non-SSS	II	−21	29.0	NE
44	46	31	M	Right	NE	Non-SSS	I	23	20.2	NE
45	47	69	M	Right	NE	Non-SSS	I	17	13.7	NE

Dist to med border, distance of MSCA from medial scapula border; *F*, female; *M*, male; *MSCA*, medial scapula corpus angle; *NE*, not evaluated; *SSS*, snapping scapula syndrome.

other 8 cases (17%), the slices selected by the observers were 2 slices apart. The costal surfaces of all corpus scapulae were described as straight, S shaped, or concave. The straight type was seen in 28 cases (60%) and was defined as type I (Fig. 3). An S-shaped scapula corpus (type II) was identified in 14 cases (30%), whereas a concave scapula corpus (type III) was seen in 5 patients (10%). The intraobserver agreement and interobserver agreement were

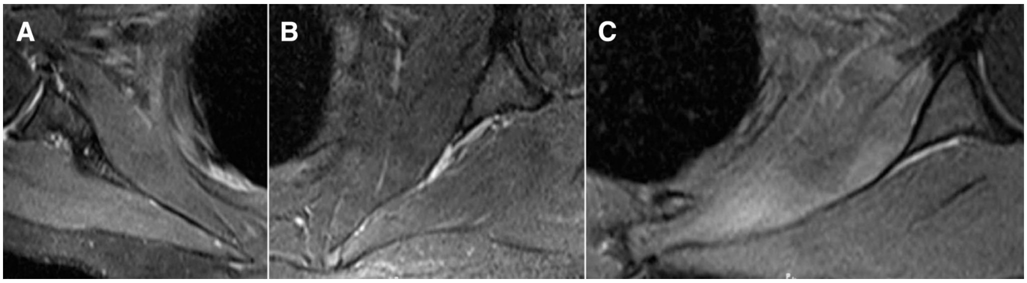

Figure 3 (**A**) An axial short tau inversion recovery sequence of the proximal right scapula of a 3.0-T magnetic resonance imaging (MRI) scan showing a straight scapula bony morphology, which was defined as a type I scapula. (**B**) Sample of an axial MRI scan, using the short tau inversion recovery sequence, of a left scapula showing a wave-shaped scapula bony morphology, which represents a type II scapula. (**C**) Sample of an axial MRI scan, using the proton density fast spin echo fat-suppressed sequence, of a left scapula showing a concave superior scapula corpus. This morphology was defined as a type III scapula. All type III scapulae were associated with snapping scapula syndrome.

excellent: 0.81 (95% confidence interval [CI], 0.67 to 0.89) and 0.88 (95% CI, 0.79 to 0.93), respectively.[6] The individual types of scapula bony morphology are listed in Table II. There were no significant differences in bony scapula morphology between the study groups ($P = .10$). However, all 5 patients with type III scapulae had SSS.

The measurement of MSCA showed substantial intraobserver agreement (0.70; 95% CI, 0.52 to 0.82) and interobserver agreement (0.80; 95% CI, 0.67 to 0.89).[6] Patient MSCAs are listed in Table II. Significant differences in MSCA were seen between group 1 and group 2, as well as between patients with type I or II scapulae and those with type III scapulae (Table III). After we excluded the 5 patients with type III scapulae, 25 patients (25 scapulae) had a positive MSCA and 16 patients (17 scapulae) had a negative MSCA. A positive MSCA was associated with SSS in 72.0% of the cases, whereas a negative MSCA was seen in 17.6% of the patients with SSS (Fig. 4). The odds ratio for SSS and a positive MSCA compared with non-SSS pathologies was 8.4 (95% CI, 2.2 to 31.8). When the 5 patients with type III scapulae were excluded, the odds ratio increased to 12.0 (95% CI, 2.6 to 55.0). The mean distance of the angulation was 14.1 mm (SD, 4.1 mm; range, 4.8 to 20.0 mm) lateral to the medial border. When only patients with SSS and a positive MSCA angle were included, the mean distance of the angulation was 13.2 mm (SD, 4.3 mm; range, 4.8 to 20.0 mm) lateral to the medial border.

The mean scapulothoracic distance of all 50 scapulae included was 19.1 mm, with large variations (SD, 7.7 mm; range, 5.0 to 42.0 mm). The patients with SSS had a significantly smaller scapulothoracic distance (mean, 14.9 mm; SD, 5.8 mm; range, 5.0 to 30.2 mm) compared with those with non-SSS pathology (mean, 24.0 mm; SD, 6.7 mm; range, 14.5 to 42.0 mm; $P < .001$).

Discussion

This study found a significant association between MSCA and the diagnosis of SSS. Angulation toward the thorax (positive MSCA) was associated with SSS, and patients with a positive MSCA were 12 times more likely to have SSS than patients with a negative MSCA. The scapulothoracic distance was significant lower in the patients with SSS. Furthermore, 3 different morphologic types of the scapula corpus were seen. All concave types were associated with SSS. Generally, both the measurement of the MSCA and the scapula corpus classification had substantial interobserver and intraobserver correlations.[6] The mean distance of the angulation was 14.1 mm (SD, 4.1 mm; range, 4.8 to 20.0 mm) lateral to the medial border. This information might have clinical relevance because there are no evidence-based guidelines on the amount of scapular resection needed in SSS patients. The MSCA may help determine the location and amount of scapular resection required to reduce symptoms in patients with SSS.

The role of bone irregularities of the scapulothoracic articulation for SSS is a subject of debate. Percy et al[16] did not document any bony abnormalities in their case series of 14 patients with SSS. However, Pearse et al[15] performed bursectomy without any scapulectomy in 9 patients with SSS and with an additional partial scapulectomy in 4 patients. The mean postoperative Constant score was higher in the group that underwent additional partial scapulectomy (83 ± 17) compared with the patients with bursectomy only (68 ± 20). In addition, several smaller case series reported good clinical outcomes after partial scapulectomy, through either open, mini-open, or arthroscopic techniques.[7-10,12,14,18]

Mozes et al[12] found bony scapulothoracic incongruity in all 26 scapulae with SSS as determined by 3D CT. They assumed that the discrepancy could be explained by the differences in the imaging modality (3D CT vs conventional radiography). They speculated that in most cases, SSS was the result of bony incongruity at the superomedial scapular angle, as well as at the medial scapula border, which causes scapulothoracic bursitis. Similarly, Edelson[4] evaluated the medial scapular border in scapulae and found an anterior angulation of more than 35° in 8.5% of the cases. Similarly, we have seen MSCAs of more than 35°

Table III MSCA by group

	Snapping scapula group				Other pathology group				*P* value
	n	MSCA, °			n	MSCA, °			
		Mean	SD	Range		Mean	SD	Range	
All patients	26	14	19	−29 to 45	21	−3	15	−26 to 28	<.001
No type III scapula	21	15	18	−29 to 45	21	−3	15	−26 to 28	<.0001

MSCA, medial scapula corpus angle.

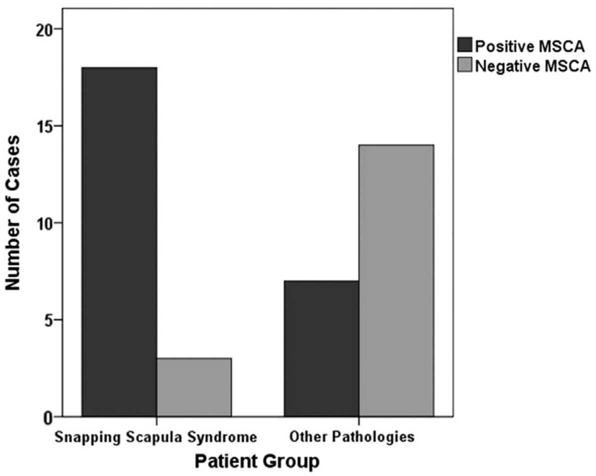

Figure 4 Distribution of negative versus positive medial scapula corpus angle (MSCA) with respect to pathology (ie, snapping scapula syndrome vs other pathologies).

in 12% of our patients (4 of 47). All 4 of these patients had SSS. In addition, we found a significantly lower scapulothoracic distance in the SSS group compared with that in patients with non-SSS pathology. These data support an association between scapula bony morphology and SSS. Generally, an angulation of the scapula corpus toward the thorax leads to a more restricted scapulothoracic space, thus increasing the risk of osseous impingement and scapulothoracic bursitis. Similarly, a concave scapula corpus increases contact pressure between the medial scapula border and the thorax, increasing the risk of impingement and inflammation. On the basis of our results, both a positive MSCA and a type III scapula are risk factors for the development of SSS.

Data about the variety of axial scapula corpus bony morphology are limited. Because the axial bony morphology of each scapula can vary considerably on the image slice section, it is important to perform a standardized measurement protocol. We defined our region of interest just below the spina scapula because we were interested in the superior third of the scapula and a reproducible selection algorithm. Our approach was reproducible based on the high agreement between observers, the observers choosing the same or adjacent MRI slices in 39 of 47 scapulae, and the high interobserver agreement. Most of our patients (59%) had a type I scapula, 31% had a type II scapula, and only 10% had a type III scapula. The clinical relevance of this finding may be questionable because no significant correlation between the scapula shape and scapula pathology was found. However, all 5 patients with type III scapulae had SSS. On the basis of this finding, we believe screening for concave scapula bodies (type III) is of clinical relevance. Generally, the distribution of the different types of scapula bony morphology seen in our cohort may not represent the distribution of a healthy collective based on the high number of SSS patients.

Several limitations apply to this study. First, this study has no ability to prove causality of variable medial scapular angles, as well as the scapula types, for the development of SSS. It is not known whether SSS is caused by these extrinsic factors or whether the pathologies lead to secondary changes of the scapula by remodeling.

Second, there might be a further improvement in the diagnostic accuracy by using CT, particularly 3D CT, to evaluate bony morphology and improve interobserver agreement. However, a preoperative MRI scan is essential to rule out soft tissue pathologies, such as tumors.[5,13,19,20] In addition, the MRI scan offered good interobserver agreement for the MSCA and scapula type by using axial short tau inversion recovery or proton density fast spin echo sequences images. The diffuse border of the medial spina scapula was an important guide, defining the correct slide in each patient. Nonetheless, a study comparing MRI and CT regarding the evaluation of the scapula bony morphology would be of great interest. This would help us to answer the question of whether it is worthwhile to perform an additional CT scan, leading to considerable radiation for patients and increasing the cost.

Third, the sagittal images were not considered in this study. The initial evaluation of the sagittal images was unremarkable. The measurement of the scapulothoracic space showed significant differences between the groups. However, the variance for the measurement was too high and might have been caused by a lack of standardization of the patient position during the MRI procedure. To gain comparable measurements, a standardized imaging procedure would be essential, including a standardized patient position, particularly with respect to the shoulder and arm position. Future studies are warranted to define a standardized imaging procedure and evaluate any further association between the scapulothoracic distance and SSS.

Conclusion

The scapula corpus bony morphology in the axial plane had an association with SSS. Patients with a concave-shaped scapula and positive MSCA have a 12-fold increased risk of SSS. Although this study does not demonstrate causation, a significant association was found.

Disclaimer

Peter J. Millett received royalties and consultant payments from Arthrex, which are not related to the subject of this work, and has stock options with GameReady and VuMedi. All the other authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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