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ORIGINAL ARTICLE

Acromioclavicular joint arthrosis in persons with spinal cord injury and able-bodied persons

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Objective: To compare the prevalence, severity and risk of acromioclavicular (AC) joint arthrosis in persons presenting with shoulder pain between a spinal cord injury (SCI) and able-bodied population. In the SCI population, prevalence and severity of AC joint arthrosis were examined with respect to age, gender and lesion characteristics.

Methods: Retrospective analysis of medical records and magnetic resonance images (MRI) collected in an outpatient orthopaedics clinic.

Results: Sixty-eight persons with SCI and 105 able-bodied persons were included in the study. The overall MRI prevalence of AC joint arthrosis was 98% and 92%, respectively. In both groups AC joint arthrosis was frequently accompanied by MRI diagnosis of rotator cuff tears and biceps tendon ruptures. Sensitivity of clinical testing was found to be low in SCI (0.31) and in able-bodied persons (0.24). The odds of increasingly severe arthrosis were nearly four times higher in persons with SCI as compared with able-bodied persons ($P<0.0001$), about 72% lower in females as compared with males ($P=0.0001$), and 10% higher per additional year of age ($P<0.0001$). Arthrosis severity in the SCI-group was weakly associated with time since injury, not with neurological classification of SCI or level of injury (paraplegia vs tetraplegia).

Conclusion: SCI patients presenting with shoulder pain showed similar prevalence, yet more advanced, AC joint arthrosis than able-bodied patients. As early diagnosis of arthrosis is a prerequisite for the initiation of successful conservative interventions of shoulder deterioration, we recommend routine assessment of shoulder status including diagnostic imaging during check-ups.
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Keywords: spinal cord injury; pain; acromioclavicular joint; shoulder; arthrosis

INTRODUCTION

Shoulder pain is a frequently reported problem in persons with a spinal cord injury (SCI), with prevalences varying between 30 and 70%.[1–3] Overuse is described as a major cause of shoulder pain in wheelchair-dependent persons with SCI.[4] Especially transferring and weight-relief lifting, as well as wheelchair propulsion, are related to a high and/or repetitive strain on the shoulder.[5–7] Commonly encountered pathologies causing shoulder pain include subacromial impingement,[8] tendinopathy and rotator cuff tears.[9]

In the able-bodied population arthrosis of the acromioclavicular (AC) joint has been described as a common source of shoulder pain that is often not recognized by clinicians and researchers[10] and might masquerade other shoulder conditions. In SCI degenerative changes of the AC joint are less commonly described as a cause for shoulder pain.[9,11] Among 28 persons with paraplegia, Boninger *et al.*[11] found a prevalence of 64% and 43% for AC joint degenerative disease and AC joint oedema, respectively. In the study of Akbar *et al.*[9] the prevalence of AC joint arthrosis in persons presenting with and without pain was 43%, which was significantly higher than in the for age and gender matched control group (26%).

Early diagnosis and insight in the risk profiles of AC joint arthrosis in persons with SCI are relevant, because treatment options are reduced and often restricted to challenging surgical interventions with increasing arthrosis severity.

The aim of the present study was to investigate the prevalence, severity and risk of AC joint arthrosis by magnetic resonance imaging (MRI) in persons with SCI, compared with an able-bodied population, both presenting with shoulder pain. A second aim was to study the sensitivity and specificity of clinical examination in persons using MRI as a gold standard.

The third aim of the study was to investigate the association between level and neurological classification of SCI, age, gender and time since injury (TSI), with prevalence and severity of AC joint arthrosis in the SCI population. It was hypothesized that there would be an increase in the prevalence and severity of AC joint arthrosis in the elderly and those with a longer TSI and no relationship with gender, level and neurological classification.

MATERIALS AND METHODS

Study design

The present study was a retrospective analysis of medical records and MRI.

The study was approved by the ethical committee of the canton Luzern, Switzerland and is in accordance with the ethical standards in the 1964 Declaration of Helsinki.

Included were all persons with SCI as well as able-bodied persons, who presented with shoulder pain and were assessed at the outpatient orthopaedics clinic of the Swiss Paraplegic Center (Nottwil, Switzerland) between January 2007 and December 2009.

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Participants

Participants were 18 years or older and SCI participants had to be wheelchair dependent. Excluded were participants with any systemic joint disease.

From the patient records, date of birth and gender were retrieved. For participants with SCI, the TSI, the level of SCI (paraplegia vs tetraplegia) and the neurological classification of SCI according to the International Standards for Neurological and Functional Classification of Spinal Cord Injury (ASIA Impairment Scale (AIS))[12] were also retrieved from patient records.

Assessments

Clinical assessment of the shoulder was performed in all patients using multiple tests. For AC joint arthrosis especially palpation of the AC joint and the cross-body adduction test were included. For rotator cuff tears several tests were performed, including cross-body adduction test, lift-off test and empty-can test. The clinical examination for AC joint arthrosis, and respectively rotator cuff tears, was scored positive if one of the tests was positive.

All participants underwent MRI following a standardized protocol as part of their medical checkup. All imaging was performed on a 3-T MRT unit (Philips, Amsterdam, The Netherlands) with a shoulder coil and acquired with proton density weighted (PDW), PDW inversion recovery (Spectral Attenuated Inversion Recovery, SPAIR), T1 weighted and T1-weighted inversion recovery (Spectral Presaturation Inversion Recovery, SPIR) sequences after intra-articular contrast application. MRIs were assessed by an experienced musculoskeletal radiologist. Ten per cent of the MRIs were re-assessed blinded to calculate the intra-rater reliability.

AC joint arthrosis severity and presence of bone oedema was classified according to the classification of Shubin–Stein[13] (Figure 1).

Tendons of the rotator cuff muscles (supraspinatus, infraspinatus and subscapularis) as well as the long tendon of the biceps muscle were (assessed and) graded depending on tendinopathy, partial, transmural or complete rupture.

Analyses

Basic statistics were used to describe demographic characteristics, clinical tests, MRI and their associations. Ordered logistic regression was used to evaluate adjusted odds ratios for more severe arthrosis in MRI findings (stepwise progressive from Grade 1 to Grade 4) in univariable and a multivariable models, using study group (SCI vs able-bodied), age (in years) and sex as predictor variables. In sensitivity analysis the effect of age was investigated as categorical variable (three age groups: <40; 40–59; and >60). Effect modification was investigated by adding mutual interaction terms between the predictor variables to the multivariable model. The likelihood ratio test was used to estimate significance of effects. To verify the basic assumption parallel lines (that is, same slopes) in ordered logistic regression modelling the Brant test was used as global test and for each variable separate.[14] Risk factors for AC joint arthrosis severity in the SCI group were investigated in a separate model using TSI, age (in years), sex and AIS score (tested with four levels and tested A (complete) vs B,C and D (incomplete) as predictor variables. Multiple imputation was used to account for the missing of the AIS score in one participant. In a second model the effect of level of injury as a risk factor for AC joint arthrosis severity was investigated, using TSI, age (in years), sex and level of injury (paraplegia vs tetraplegia) as predictor variables. α-Error was set at 0.05 and all reported *P*-values are two sided. Stata 11.2 software (StataCorp LP, Texas, USA) was used in statistical analysis.

Chronbach's alpha was calculated to measure the intra-rater reliability of the MRI assessments.

RESULTS

Patient demographics

Sixty-eight persons with SCI and 105 able-bodied persons were included in the study. Table 1 gives an overview of the participants' characteristics. The SCI and able-bodied group showed a similar

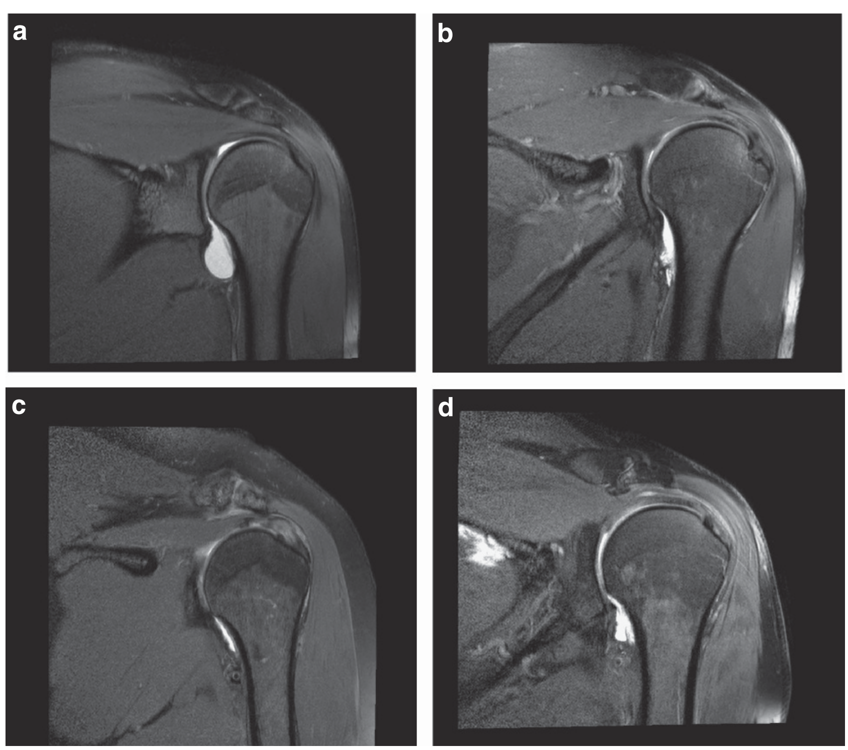

Figure 1 (**a**–**d**) Acromioclavicular joint arthrosis classified by Shubin–Stein: (**a**) Grade I; no capsular distension, no joint space narrowing, and no evidence of osteophyte formation, (**b**) Grade II; capsular distension, frequently an isolated finding but occasionally accompanied by mild joint space narrowing, (**c**) Grade III; capsular distension with a combination of joint space narrowing, subacromial fat effacement and marginal osteophyte formation and (**d**) Grade IV; all of in Grade I, II and III mentioned findings in addition to marked joint space irregularity and narrowing with large osteophytes. All images acquired with proton density weighted (PDW), PDW inversion recovery (Spectral Attenuated Inversion Recovery, SPAIR), T1 weighted and T1 weighted inversion recovery (Spectral Presaturation Inversion Recovery, SPIR) sequences after intra-articular contrast application.

distribution in age and sex. Within the SCI group, level of injury was paraplegia and tetraplegia in 72% and 28%, respectively. The predominant AIS score (80%) was A. The mean TSI was 23.3 years and not related to lesion level ($P=0.27$).

Table 2 displays the descriptives of clinical findings and MRI examination for AC joint pathology, rotator cuff tears and biceps tendon tears and the *P*-values for between group differences.

Prevalence, severity of AC joint arthrosis, sensitivity and specificity of clinical examinations

The sensitivity and specificity of clinical examinations for AC joint arthrosis using MRI diagnosis as a gold standard is displayed in Table 3. Clinical examination in the SCI and able-bodied group showed high specificity (100% and 71%, respectively), but low sensitivity (31% and 24%, respectively). Using two-tailed Fischer's exact test showed no significant association between clinical examination and MRI findings ($P=1$ for SCI group and $P=0.66$ for able-bodied group). The low number of 'cases' per cell does not allow to calculate the differences between the SCI and able-bodied group.

MRI findings in participants with SCI showed an overall prevalence of AC joint arthrosis of 98%. In the able-bodied group, prevalence of AC joint arthrosis on MRI was 92% (Figure 2). Bone oedema was present in 13% ($n=9$) in the SCI group and in 22% ($n=23$) in the able-bodied group.

Chronbach's alpha intra-rater reliability was 0.95 for prevalence and severity of AC joint arthrosis and 0.77 for presence of bone oedema.

Risk factors for AC joint arthrosis

The odds of increasingly severe arthrosis, holding all other variables constant, were nearly fourtimes higher in persons with SCI as compared with able-bodied persons (adjusted odds ratio = 3.82, 95% confidence interval (CI): 2.03–7.21; $P<0.0001$); about 72% lower in females as compared with males (adjusted odds ratio = 0.28, 95% CI: 0.14–0.54; $P=0.0001$); and 10% higher per additional year of age (adjusted odds ratio = 1.10, 95% CI: 1.07–1.12, $P<0.0001$;

Table 1 Descriptive statistics of the study population

	SCI group	*Able-bodied group*	*P-value*
Number of persons	68	105	—
Age (years; range)	51 (21–79)	53 (18–80)	0.40
Male	53 (78%)	69 (66)	0.085
Level of injury	—	NA	NA
Paraplegia	49 (72%)	—	—
Tetraplegia	19 (28%)	—	—
AIS score	—	NA	NA
A	54 (80%)	—	—
B	6 (9%)	—	—
C	5 (7%)	—	—
D	2 (3%)	—	—
Unknown (missing)	1 (1%)	—	—
TSI (years, range)	23 (0–48)	NA	NA

Abbreviations: AIS, ASIA impairment scale; NA, not applicable; SCI, spinal cord injury, TSI, time since injury.

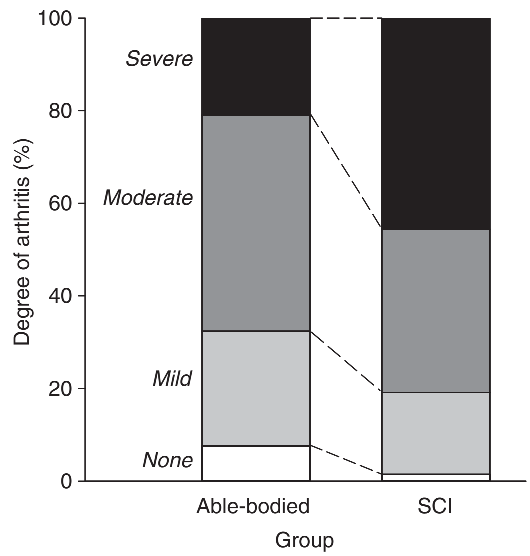

Figure 2 Degree of AC joint arthrosis by group, as classified by Shubin–Stein.[13]

Table 2 Descriptive statistics of clinical tests and MRI diagnosis of the population

	SCI group (n = 68)			*Able-bodied group (n = 105)*			*P-value*
	Positive	*Negative*	*Unknown/not judge able*	*Positive*	*Negative*	*Unknown/not judge able*	
Clinical examination							
AC joint	19 (28%)	43 (63%)	6 (9%)	21 (21%)	64 (60%)	20 (19%)	0.133
RCT	27 (40%)	39 (57%)	2 (3%)	40 (38%)	52 (50%)	13 (12%)	0.093
MRI diagnosis							
AC joint arthrosis	67 (99%)	1 (1%)	—	96 (91%)	9 (9%)	—	0.051
RCT overall	50 (74%)	13 (19%)	5 (7%)	74 (70%)	30 (29%)	1 (1%)	0.041
SSP	42 (62%)	21 (31%)	5 (7%)	64 (61%)	40 (38%)	1 (1%)	—
ISP	25 (37%)	38 (56%)	5 (7%)	45 (43%)	59 (56%)	1 (1%)	—
SSC	42 (62%)	21 (31%)	5 (7%)	54 (51%)	50 (48%)	1 (1%)	—
Biceps tendon	38 (56%)	25 (37%)	5 (7%)	42 (40%)	62 (59%)	1 (1%)	0.004

Abbreviations: AC joint, acromioclavicular joint; ISP, infraspinatus muscle/tendon; MRI, magnetic resonance imaging; RCT, rotator cuff tear; SCI, spinal cord injury; SSP, supraspinatus muscle/tendon; SSC, subscapularis muscle/tendon.
P-value (calculated with χ^2 test) describes the difference between the SCI group and able-bodied group.

Table 3 Contingency table of clinical tests for AC joint arthrosis and findings on MRI in persons with SCI and able-bodied persons

	Clinical examination		
	Positive	*Negative*	*Unknown*
MRI findings in persons with SCI (n = 68)			
Positive	19 (28%)	43 (62%)	6 (9%)
Negative	0 (0%)	1 (1%)	0 (0%)
MRI findings in able-bodied group (n = 105)			
Positive	19 (18%)	59 (56%)	18 (17%)
Negative	2 (2%)	5 (5%)	2 (2%)

Abbreviations: AC joint, acromioclavicular joint; MRI, magnetic resonance imaging; SCI, spinal cord injury.

Table 4). There was no indication of effect modification (tests of interaction: for Age*Study Group, $\chi^2 = 0.06$, d.f. = 1, $P = 0.80$; for Sex*Study Group, $\chi^2 = 0.74$, d.f. = 1, $P = 0.39$). The univariate analysis gave similar results, indicating that main effects are largely independent. Further, allowing for a non-linear effect of age did not improve model fit (for comparison of model with categorical age variable: $\chi^2 = 3.40$, d.f. = 2, $P = 0.18$). Furthermore, there was no evidence for violation of the underlying parallel regression assumption (Brant test for combined variables: $\chi^2 = 4.83$, d.f. = 6, $P = 0.56$; for separate variables: all $P > 0.35$).

Risk factors in persons with SCI

Arthrosis severity in the SCI-group showed, controlling for the effects of sex and age, only a weak association with TSI (in years: adjusted odds ratio = 1.04, 95% CI: 0.99–1.09, $P = 0.078$) and no association with AIS score (tested with 4 levels A,B,C,D: $P = 0.72$; tested A (complete) vs B,C and D (incomplete): $P = 0.29$) or lesion level (paraplegia vs tetraplegia: $P = 0.32$).

DISCUSSION

The current study was performed to get more insight in the prevalence, severity and risk of AC joint arthrosis in person with SCI who presented with shoulder pain compared with an able-bodied population with shoulder pain, and to study the association between level and neurological score of SCI, age, gender and TSI with prevalence and severity of AC joint arthrosis in the SCI population.

Prevalence, severity and risk of AC joint arthrosis in person with SCI who presented with shoulder pain compared with an able-bodied population with shoulder pain

The present comparative study showed a high prevalence of AC joint arthrosis on MRI in both persons with SCI (98%) and the able-bodied persons (92%). However, controlling for variation in age and sex, the odds of having an increasingly severe arthrosis for persons with SCI was found to be nearly 4 times higher.

The relation between clinical examination and MRI findings of AC joint arthrosis showed that clinical testing has a low sensitivity (or high type II error rate) in both groups, showing an underrepresentation of AC joint arthrosis by clinical testing. The study by Brose *et al.*,[15] which investigated the presence of ultrasound abnormalities and physical examination findings in manual wheelchair users with SCI showed in 18% of the clinical exams AC joint tenderness. Ultrasound findings showed a positive trend with the Wheelchair User's Shoulder Pain Index (WUSPI) but statistical association between clinical examination and AC joint pathology on ultrasound findings was not described.

The current study showed a higher prevalence of AC joint arthrosis on MRI in both persons with SCI and able-bodied persons, than found in former studies assessing this topic using MRI. This difference in prevalence is likely related to specific study characteristics. A study of Cardogan *et al.*[16] showed only a prevalence of 17% of AC joint degeneration in able-bodied persons presenting with pain in a primary care setting. Boninger *et al.*[11] found an overall prevalence of 30% in a population that included only persons with paraplegia with and without shoulder pain, who were of younger age and had a shorter TSI (that is, 11.5 years). Akbar *et al.*[9] found a prevalence of AC joint arthrosis of 42% in persons with SCI and 26% in able-bodied persons. The study of Akbar *et al.* also included only persons with paraplegia. They found an odds ratio of having AC joint arthrosis for persons with SCI of 2.1 compared with those in the control group.

Similar to our study, Akbar *et al.* found a higher prevalence of shoulder pathology in person with SCI when controlling for age.[9] In our study group, the odds of increasingly severe arthrosis, holding all other variables constant, were 10% higher per additional year of age. This result is also in line with the study of Pennington *et al.*,[17] who studied radiological features of osteoarthritis of the AC joint and its association with clinical symptoms. The relation with age confirms the idea that AC joint arthrosis is related to repetitive strain.

Our study showed that the odds of increasingly severe arthrosis were about 72% lower in females as compared with males. This result differs from the finding of Pennington *et al.*, who did not find any association between gender and radiological features of osteoarthritis of the AC joint. Also the study of Schweitzer *et al.*,[18] studying the AC joint fluid and determination of clinical significance with MRI found no relation with gender.

Association between level and completeness of SCI, age, gender and TSI with prevalence and severity of AC joint arthrosis in the SCI population

The analysis of arthrosis severity in the SCI-group revealed, when controlling for the effects of sex and age, a weak association with TSI and no association with AIS score or lesion level. This finding is surprising, as arthrosis of the AC joint is typically thought of as a result of repetitive strain injury and therefore age and TSI was expected to be associated much stronger with AC joint arthrosis. In the one other study found addressing the relations between patient characteristics and prevalence and severity of AC joint arthrosis, the number of patients included in the study was too small to study any risk factors within the SCI group.[19]

Study limitations

The current study was performed retrospectively and therefore, relevant determinants such as physical activity (overhead sports), number of transfers and shoulder injury before SCI, were not assessed. For future studies, adding these variables would be of interest. Furthermore, shoulder pain was not assessed with a validated measurement instrument in this study. Standardized clinical tests to assess AC joint pathology, for example, the Paxinos[20] test would further increase the study quality.

CONCLUSION

The results of our study show a high prevalence of AC joint arthrosis in persons with SCI and able-bodied persons, however, a more severe degree and more advanced stage of AC joint arthrosis was found in persons with SCI (controlled for sex, age and TSI). Sensitivity of

Table 4 Unadjusted and adjusted odds ratios for AC joint arthrosis as derived from ordered logistic regression

Variables	*Unadjusted*		*Adjusted*	
	Odds ratio (95% CI)	P-*value*	*Odds ratio (95% CI)*	P-*value*
Group				
Able-bodied	1		1	
SCI	2.70 (1.50–4.85)	0.0007	3.82 (2.03–7.21)	<0.0001
Sex				
Male	1		1	
Female	0.39 (0.22–0.72)	<0.0001	0.28 (0.14–0.54)	0.0001
Age (years)	1.07 (1.05–1.10)	0.002		1.10 (1.07–1.12)

Abbreviations: AC joint, acromioclavicular joint; SCI, spinal cord injury.
P-values were obtained from likelihood ratio tests.

clinical testing is found to be low. Routine assessment during check-ups, which includes assessment of shoulder pain, physical examination and diagnostic imaging (X-ray and when necessary MRI), might help to diagnose AC joint arthrosis at an earlier stage. Early diagnosis is a prerequisite for successful conservative interventions (e.g. optimizing transfer techniques, technique of wheelchair propulsion) of further shoulder deterioration.

DATA ARCHIVING

There were no data to deposit.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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