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ORIGINAL REPORT

RELATIONSHIP BETWEEN SEVERITY OF SHOULDER SUBLUXATION AND SOFT-TISSUE INJURY IN HEMIPLEGIC STROKE PATIENTS

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Objective: **The aims of this study were: (*i*) to determine whether the severity of post-hemiplegic shoulder subluxation in stroke patients correlates with soft-tissue injury; and (*ii*) to determine the shoulder subluxation measurement cut-off points that are indications for further ultrasound examination for soft-tissue injuries in these patients.**
Design: **Cross-sectional study.**
Patients: **A total of 39 stroke patients with shoulder subluxation.**
Methods: **Shoulder subluxation was evaluated by physical examination, radiography and ultrasound. Soft-tissue injuries were assessed by ultrasound. Subluxation parameters were entered into stepwise logistic regression analyses to predict biceps and supraspinatus tendonitis. With the assumption that shoulder subluxation can be a predisposing factor for tendonitis, receiver operating characteristic curves for shoulder subluxation parameters of the affected side were used to determine cut-off points for optimal sensitivity and specificity of biceps and supraspinatus tendonitis.**
Results: **Shoulder subluxation lateral distance, measured by physical examination, is a predictor for supraspinatus tendonitis (odds ratio = 34.9, $p = 0.036$). Further ultrasound investigation for soft-tissue injury is indicated when subluxation lateral distance, measured by physical examination is ≥2.25 cm or, measured by radiographic examination, ≥3.18 cm for lateral distance, ≥3.08 cm for vertical distance, or ≥2.65 cm for horizontal distance.**
Conclusion: **When post-hemiplegic shoulder subluxation measurements exceed the above-mentioned cut-off points in physical or radiographic examinations, further ultrasound evaluation for soft-tissue injury is recommended.**

Key words: shoulder subluxation; ultrasound; stroke; tendonitis; radiograph; soft-tissue injuries.

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INTRODUCTION

Shoulder subluxation, defined as increased translation of the humeral head relative to the glenoid fossa, can interfere with rehabilitation and has negative effects on motor function recovery when post-hemiplegic shoulder pain occurs (1). Although post-hemiplegic shoulder pain often occurs with subluxation, the correlation between these factors is controversial. Investigation into the major factors leading to post-hemiplegic shoulder pain is warranted. Previous research has not shown any correlations between shoulder pain and gender, time since onset of disease, hemiplegic side, pathogenesis, spasticity, neglect, and thalamic pain (2). An ultrasound study indicated that the cause of post-stroke shoulder pain can vary and is not related to motor recovery status (3). An arthroscopic study found that the causes of hemiplegic shoulder pain are complex and that shoulder subluxation is one of the major causes (4). Conversely, another study reported that there was no correlation between shoulder subluxation and shoulder pain (5). It has also been reported that a high incidence of shoulder pain occurs in stroke patients as a result of tendonitis, effusion, or bursitis in hemiplegic shoulders (6). An ultrasound study found that acute stroke patients with poor upper limb motor function are more vulnerable to soft-tissue injuries during rehabilitation, and a higher incidence of shoulder subluxation and higher frequency of shoulder pain were found in this group (7). Traction damage to the inferior subluxation in flaccid shoulders occurs due to gravitational pull and poor protection offered by a weak shoulder girdle (8, 9). Thus, reduced strength in the post-hemiplegia shoulder may result in greater vulnerability to shoulder subluxation, soft-tissue injury and shoulder pain. However, the correlation between shoulder subluxation and soft-tissue injuries has not been studied previously.

There are many methods for evaluation of shoulder subluxation. In clinical practice, shoulder subluxation is detected by palpation of the glenohumeral joint while the patient maintains an upright posture. Radiography has also been used to evaluate the severity of post-hemiplegic shoulder subluxation (10–12), based on a comparison between the affected and unaffected shoulders, with the patient in a sitting posture allowing gravity to pull both shoulders down. This method not only seems to provide more objective and precise measurements than physical examination, which was used before musculoskeletal ultrasound became popular (13), but can also be used to access bony lesions of the shoulder. Nonetheless, when anterior or posterior shoulder subluxation occurs, it is difficult to evaluate the severity of subluxation using anterior–posterior radiography. Moreover, this type of imaging does not reveal

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whether there is soft-tissue injury in the affected shoulder, and the risk of ionizing radiation and lack of real-time presentation are limitations of this method (14). To the best of our knowledge, there have been only two studies in which ultrasound has been used to evaluate post-hemiplegic shoulder subluxation in stroke patients. Park et al. (15) compared radiographic and ultrasound methods for evaluation of post-hemiplegic shoulder subluxation, and found that ultrasound correlated more closely with clinical presentation. Kumar et al. (16) found that ultrasound measurement of the acromion to greater tuberosity distance has good intra-rater reliability and validity for post-hemiplegic shoulder subluxation. In addition to evaluation of subluxation, ultrasound can be applied at the same time for evaluation of soft-tissue injury of the shoulder. However, ultrasound examination is operator dependent and adequate training is required to achieve precise diagnosis. It is necessary to determine, therefore, whether patients with post-hemiplegic shoulder subluxation who have undergone physical or radiographic examination should be referred to ultrasound examination.

An earlier study of recent stroke patients with hemiplegic upper limbs found that soft-tissue injuries were associated with a low Brunnstrom stage (17). Indeed, it appears that post-hemiplegic shoulder subluxation may be a predisposing factor for rotator cuff injury in stroke patients, although the association between post-hemiplegic shoulder subluxation and rotator cuff injury is not well understood.

The aim of the present study was to investigate whether severity of shoulder subluxation, measured by physical, radiographic and ultrasound examination, is a predictor for soft-tissue injury. In addition, we identified the cut-off points in different subluxation examination methods that indicate a requirement for further ultrasound examination for soft-tissue injury.

METHODS

Participants

From June 2009 to July 2010, acute stroke patients presenting with hemiplegia and shoulder subluxation were recruited to the study. Inclusion criteria were: first-time stroke diagnosis; onset within 3 months of enrolment; and clinical screening showing a palpable gap between the acromion and the humeral head. Exclusion criteria were: prior shoulder disorders that impaired the movement of the shoulder joints; severe cognitive impairment; or poor trunk control that prohibited the maintenance of an upright sitting posture required for shoulder evaluation. Informed consent was obtained from all participants, and the study was approved by the institutional review board before patients were recruited. Patients were evaluated by physical examination, ultrasound and radiography. All evaluations were conducted and completed within 3 days in order to prevent measurement bias resulting from the course of stroke recovery.

Measurements

Clinical evaluation. Within 3 months of stroke onset, patients were admitted to the rehabilitation ward, and underwent a physical examination to determine subluxation-eligible cases. At the same time, demographic data (age, gender, body weight and body height), Brunnstrom's stage, visual analogue pain scale (VAS), the motor component of the functional independence measurement (M-FIM; range 13–91, with 13 being totally dependent and 91 being totally independent), and the modified Ashworth scale (MAS; range 0–5, with 0 representing no spasticity and 5 representing extreme spasticity) measurements were conducted (18).

Physical examination for shoulder subluxation. The distance between the inferior border of the acromion and the upper border of the humeral head was measured, as determined by palpation, with a tape measure. The subacromion gap measurement was determined using a tape-measure with the patient sitting unsupported in an upright posture without a backrest or armrests, with the arm in a neutral position hanging by the side of the body (Fig. 1). All the physical evaluation and examination parameters were obtained by a physiatrist with more than 3 years of experience who was blind to the radiographic and ultrasound outcome.

Radiographic examination for shoulder subluxation. During the shoulder X-ray examination, patients were instructed to sit with an upright posture with the arm in a neutral position hanging down under gravity. Radiographic projections were taken in the anterior–posterior direction for both the affected and unaffected shoulders. To measure shoulder subluxation, we used the method described by Brooke et al. (19), which uses 3 reference points (the central point of the glenoid fossa, the central point of the humeral head, and the most inferior lateral point on the acromion surface of the acromioclavicular joint) to measure the vertical and horizontal dimensions of the glenohumeral joint. The vertical distance was measured from the inferior acromial point to the central point of the humeral head, and the horizontal distance was measured from the central point of the glenoid fossa to the central point of the humeral head. The lateral distance was measured from the lateral border of the acromion to the greater tuberosity of the humerus in order to make a direct comparison of the physical and ultrasound measurements of subluxation (Fig. 2). These distances were measured by a radiologist who was blinded to the results of the clinical screenings.

Ultrasound examination for shoulder soft-tissue injury and subluxation. Ultrasonography of the shoulder was undertaken by one physiatrist who had at least 5 years of experience and who was certified by the Chinese Ultrasound Academy. The physiatrist was not notified of the results of the radiographic or clinical evaluations. Both affected and unaffected shoulders were examined for comparison. A 5–12 MHz high-resolution linear scanner (Philips HD-11XE, Philips Location, The Netherlands) was used for the ultrasound examination, and patients were evaluated while maintaining a sitting posture. The techniques for evaluating shoulder muscles and tendons were adapted from the methods of Middleton (20). The biceps, supraspinatus, subscapularis

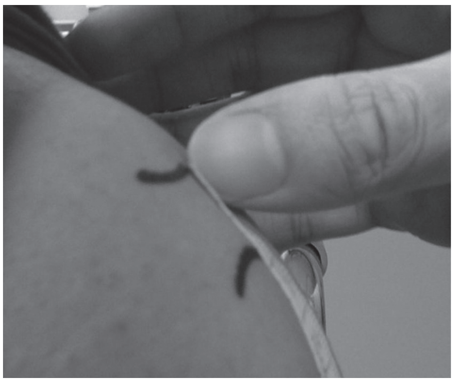

Fig. 1. Physical examination of shoulder subluxation. Shoulder subluxation was measured by palpating the lateral border of the acromion and the greater tuberosity of the humerus bone and measuring the distance between them using a tape measure.

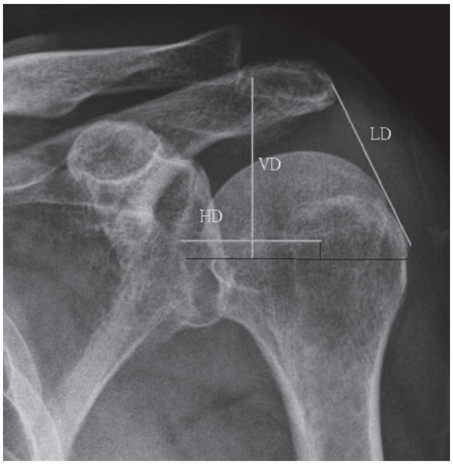

Fig. 2. Radiographic examination of shoulder subluxation. The lateral distance (LD) was measured from the lateral border of the acromion to the greater tuberosity of the humerus, vertical distance (VD) was measured from the inferior acromial point to the central point of the humerus head, and the horizontal distance (HD) was measured from the central point of the glenoid fossa to the central point of the humerus head.

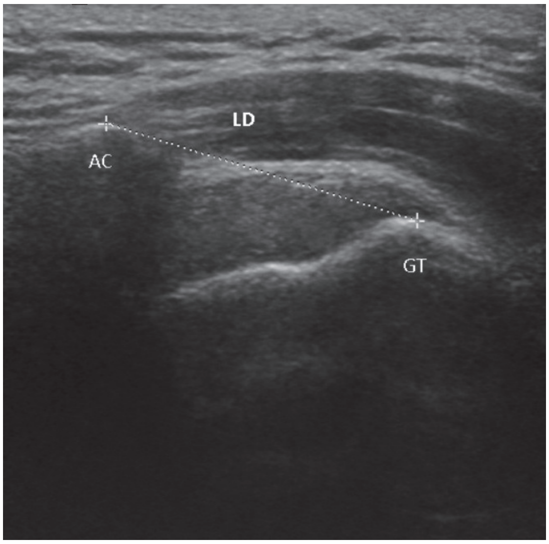

Fig. 4. Ultrasound measurement of shoulder subluxation: the lateral distance (LD) was measured from the lateral border of the acromion to the greater tuberosity of the humerus. AC: acromion, GT: greater tuberosity.

and infraspinatus were evaluated in this study using both longitudinal and transverse views. The findings of ultrasound examinations were classified as either normal, tear, or tendonitis. A tear was defined as a discontinuity in the normal homogeneous echogenicity of the tendon (Fig. 3A), whereas tendonitis was defined as a thickening or hypoechogenicity of the tendon in the absence of a border defect (Fig. 3B). According to the method described by Kumar et al. (9), the subluxation distance was measured by determining the distance from the lateral border of the acromion to the greater tuberosity of the humerus (the lateral distance; Fig. 4). The patient was seated in the same position as for physical and radiographic examination (with the arm in a neutral position hanging by their side). The lateral dimensions of both the affected and unaffected sides were measured.

Statistical analysis

Continuous variables were represented as means and standard deviations (SD). Shoulder subluxation parameters acquired through clinical examination, and radiographic vertical, horizontal and lateral dimensions for both shoulders were recorded. Student's paired t-tests were used to determine whether the dimensions for subluxation of the affected and unaffected shoulders differed significantly when evaluated by physical examination, radiography, or ultrasound. The percentage of positive findings of soft-tissue injuries for both the affected and unaffected shoulders by ultrasound examination was evaluated using McNemar's test. The outcomes of the shoulder subluxation examination were entered into a backward stepwise bivariate logistic regression for predicting biceps and supraspinatus tendonitis. Although shoulder subluxation is not a definite diagnostic tool for tendonitis, we assume that it can be a predisposing factor. Receiver operating characteristics (ROC) curves for shoulder subluxation parameters of the affected side were generated by plotting the sensitivity against 1 minus the specificity. The area under the curve was calculated with a 95% confidence interval (CI). Optimal cut-off points for tendonitis were selected based on the ROC curve analysis. Kappa symmetry was analysed to determine the consistency of the ultrasound findings. Backward stepwise

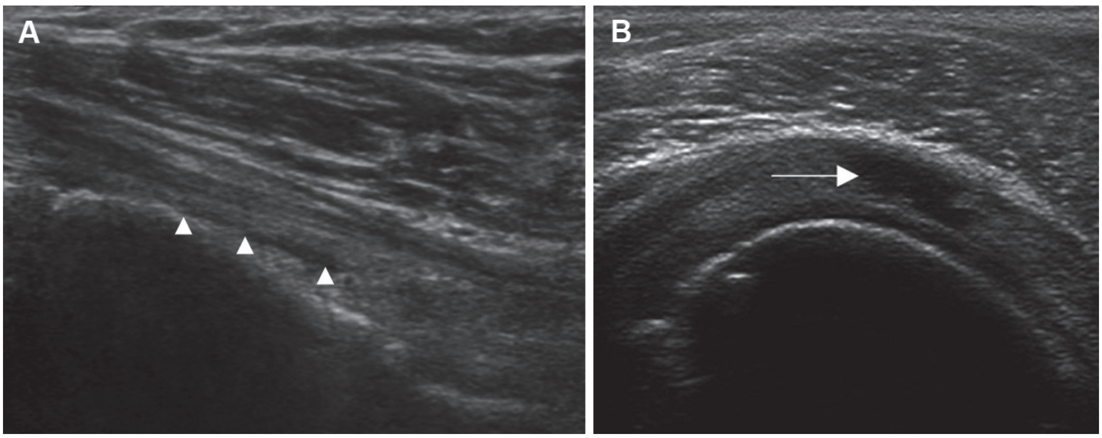

Fig. 3. Ultrasound evaluation for shoulder soft-tissue injury. (A) Tendonitis: this longitudinal view of the bicipital tendon revealed hypoechogenecity (arrowhead) around the tendon sheath and heteroechogenecity of the tendon, which indicates inflammation with fluid infiltration. (B) Tear: this transverse view of the supraspinatus tendon revealed discontinuity of the tendon with a gap (arrow) along the tendon pathway, which indicates tendon tear.

multi-variant logistic regression was analysed for odds ratio evaluation when shoulder subluxation parameters exceeded the cut-off point. SPSS version 17.0 software was used for the statistical analyses, with a *p*-value < 0.05 being considered statistically significant.

RESULTS

A total of 137 stroke patients were admitted to the rehabilitation ward and assessed for study eligibility. Of these, 98 were excluded: 63 did not meet inclusion criteria, 31 were excluded on the basis of poor cognitive ability, or lack of proper trunk balance to maintain a sitting posture during testing, and 4 did not consent to participate. A total of 39 patients (mean age 65 years (SD 11); mean body weight 65.4 kg (SD 14.1); mean body height 162.6 cm (SD 8.4); 56% male, 44% female; 74% ischaemic type stroke, 26% haemorrhagic type stroke) were recruited to this study. All evaluations were conducted within 3 days, a mean of 22 (SD 9) days after the onset of stroke. Four patients were categorized as Brunnstrom stage I, 21 patients as stage II, 5 patients as stage III, and 9 patients as stage IV. Additional measures of clinical characteristics and functionality averaged for all participants were as follows: M-FIM, 39.46 (SD 11.64; median 36; interquartile range (IQR) 32–47); MAS, 1.38 (SD 0.75; median 1; IQR 1–2); VAS, 2.95 (SD 1.62; median 3; IQR 2–4).

The shoulder subluxation measurement outcomes determined using different methods are shown in Table I. The measurements for the affected side were significantly greater than for the unaffected side by physical, radiographic and ultrasound shoulder subluxation examination. The unaffected side had significantly fewer shoulder soft-tissue injury events than the affected shoulder (Table II).

In light of the results in Table II, we focused on early detection of biceps and supraspinatus tendonitis, which occurred more often than other soft-tissue injuries in the affected side compared with the unaffected side ($p<0.001$). Backward stepwise bi-variant logistic regression showed that lateral distance assessed by physical examination was a predictor (odds ratio = 34.9, $p=0.036$) for supraspinatus tendonitis (Table III).

The area under the ROC curve for the diagnosis of biceps and supraspinatus tendonitis by the different methods is shown in Fig. 5 and Table IV.

Table II. *Soft-tissue injuries of affected and unaffected shoulders: comparison by ultrasound (*n *= 39)*

Parameters	Affected side *n* (%)	Unaffected side *n* (%)	*p*-value
Biceps			
Tendonitis	30 (76.9)	5 (12.8)	< 0.001**
Tear or rupture	3 (7.7)	0 (0)	0.250
Subscapularis			
Tendonitis	7 (17.9)	1 (2.6)	0.031*
Tear or rupture	4 (10.3)	0 (0)	0.125
Supraspinatus			
Tendonitis	14 (35.9)	1 (2.6)	< 0.001**
Tear or rupture	7 (17.9)	1 (2.6)	0.031*
Infraspinatus			
Tendonitis	8 (20.5)	1 (2.6)	0.039*
Tear or rupture	1 (5.1)	1 (5.1)	1.000
Impingement	11 (28.2)	1 (2.6)	0.002*

*$p<0.05$, **$p<0.001$ from McNemar test.

The cut-off points for detection of tendonitis of the biceps and supraspinatus muscles were 2.25 cm by physical examination, 3.18 cm by X-ray lateral distance, 3.08 cm by X-ray vertical distance, 2.65 cm by X-ray horizontal distance, and 2.5 cm by ultrasound lateral distance. The kappa symmetric measure indicated consistency ($p=0.003$) when evaluating the vertical distance by X-ray imaging, with 80% sensitivity and 77.8% specificity for detection of biceps tendonitis if the vertical measurement was more than 3.08 cm. The sensitivity and specificity of the cut-off points for different shoulder subluxation evaluation methods used to diagnose biceps and supraspinatus tendonitis are shown in Table V. For biceps tendonitis or tenosynovitis, measurement of vertical distance by radiography is more specific and has a greater positive and negative predictive value. For supraspinatus tendonitis, ultrasound has a higher negative predictive value, but lateral distance by radiograph has a higher predictive value. Backward stepwise multi-variant logistic regression revealed that a radiographic vertical distance greater than 3.08 cm is an independent predictor for biceps tendonitis (odds ratio = 11.5, $p=0.020$) and a horizontal distance greater than 2.65 cm is an independent predictor for supraspinatus tendonitis (odds ratio = 9.1, $p=0.034$) (Table VI).

Table I. *Shoulder subluxation distance examination by physical, radiographic and ultrasound methods (*n *= 39)*

Parameters	Affected side	Unaffected side	*p*-value
Physical examination, cm, mean (SD)			
Lateral distance	2.55 (0.43)	1.95 (0.29)	< 0.001
X-ray, cm, mean (SD)			
Lateral distance	3.37 (0.38)	3.10 (0.39)	< 0.001
Vertical distance	3.44 (0.58)	3.13 (0.53)	< 0.001
Horizontal distance	2.80 (0.31)	2.60 (0.35)	< 0.001
Ultrasound, cm, mean (SD)			
Lateral distance	2.93 (0.48)	2.12 (0.29)	< 0.001

p-value by paired *t*-test, 3 shoulder subluxation examination methods were performed with stroke participants in the same posture.
SD: standard deviation.

Table III. *Shoulder subluxation evaluation parameters as adjusted predictors for biceps and supraspinatus tendonitis*

	β	SE	aOR	*p*-value	R^2
Biceps tendonitis					
X-ray VD	1.7	1.0	5.7	0.073	3.2
Supraspinatus tendonitis					
US LD	2.7	1.6	15.2	0.092	2.8
PE LD	3.6	1.7	34.9	0.036*	4.4
X-ray HD	3.0	1.6	19.6	0.066	3.4

*$p<0.05$ by bi-variate logistic regression.
VD: vertical distance; US LD: ultrasound lateral distance; PE LD: physical examination lateral distance; HD: horizontal distance; SE: standard error; aOR: adjusted odds ratio.

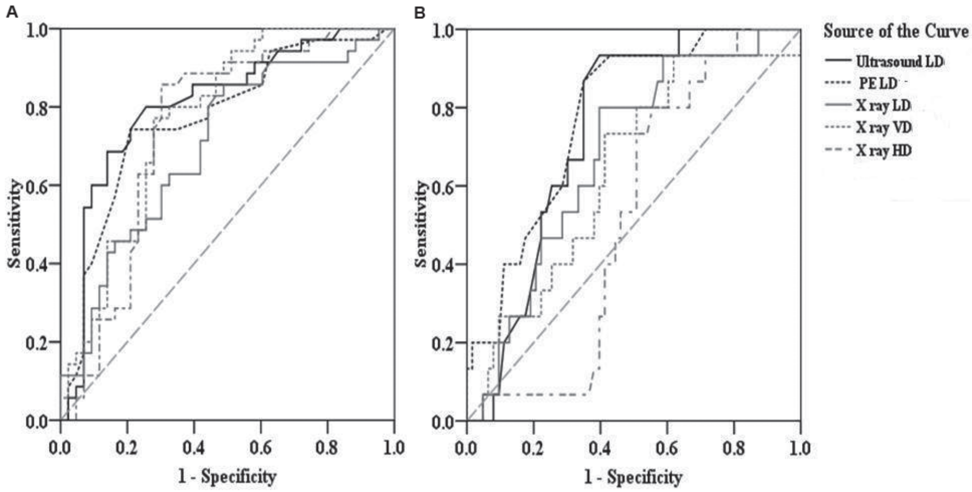

Fig. 5. Receiver operating characteristic (ROC) curves depicting the sensitivity and specificity of (A) biceps tendonitis and (B) supraspinatus tendonitis determined by different methods of evaluating shoulder subluxation.

Table IV. *Shoulder subluxation distance parameters adopted as biceps and supraspinatus tendonitis diagnostic methods by receiver operating characteristic (ROC) analysis*

Affected side	Biceps tendonitis				Supraspinatus tendonitis			
Test result variables (cm)	Area	SE	95% CI	*p*-value	Area	SE	95% CI	*p*-value
US LD	0.807	0.052	0.706–0.908	<0.001	0.744	0.057	0.633–0.855	0.003
PE LD	0.770	0.055	0.662–0.877	<0.001	0.780	0.058	0.666–0.894	0.001
X-ray LD	0.701	0.060	0.584–0.818	0.002	0.680	0.069	0.544–0.816	0.031
X-ray VD	0.769	0.053	0.666–0.873	<0.001	0.639	0.076	0.491–0.787	0.095
X-ray HD	0.744	0.058	0.630–0.857	<0.001	0.520	0.067	0.388–0.652	0.815

US LD: ultrasound lateral distance; PE LD: physical examination lateral distance; LD: lateral distance; VD; vertical distance; HD: horizontal distance; SE: standard error; CI: confidence interval.

Table V. *Biceps tendonitis sensitivity and specificity when subluxation exceeds cut-off points by different methods*

		No		Yes							
Affected side (cm)	(*n*=39)	No	%	No	%	*p*-value[a]	Kappa	*p*-value[b]	Sensitivity	Specificity	PPV
Biceps tendonitis											
US LD	<2.5	2	5.1	3	7.7	0.344					
	≥2.5	7	17.9	27	69.2		0.145	0.572	0.900	0.222	0.794
PE LD	<2.25	3	7.7	6	15.4	1.000					
	≥2.25	6	15.4	24	61.5		0.133	0.654	0.800	0.333	0.800
X-ray LD	<3.18	4	10.3	8	20.5	0.581					
	≥3.18	5	12.8	22	56.4		0.159	0.416	0.733	0.444	0.815
X-ray VD	<3.08	7	17.9	6	15.4	0.289					
	≥3.08	2	5.1	24	61.5		0.500	0.003	0.800	0.778	0.923
X-ray HD	<2.65	6	15.4	7	17.9	0.344					
	≥2.65	3	7.7	23	59.0		0.375	0.039	0.767	0.667	0.885
Supraspinatus tendonitis											
US LD	<2.5	5	12.8	0	0.0	<0.001					
	≥2.5	20	51.3	14	35.9		0.152	0.139	1.000	0.200	0.412
PE LD	<2.25	7	17.9	2	5.1	<0.001					
	≥2.25	18	46.2	12	30.8		0.110	0.445	0.857	0.280	0.400
X-ray LD	<3.18	9	23.1	3	7.7	0.004					
	≥3.18	16	41.0	11	28.2		0.121	0.477	0.786	0.360	0.407
X-ray VD	<3.08	9	23.1	4	10.3	0.012					
	≥3.08	16	41.0	10	25.6		0.063	0.733	0.714	0.360	0.385
X-ray HD	<2.65	6	15.4	7	17.9	0.029					
	≥2.65	19	48.7	7	17.9		–0.219	0.157	0.500	0.240	0.269

p-value[a] by McNemar test. *p*-value[b] by kappa symmetric measure.
US LD: ultrasound lateral distance; PE LD: physical examination lateral distance; LD: lateral distance; VD; vertical distance; HD: horizontal distance; PPV: positive predictive value.

Table VI. *Risk of biceps and supraspinatus tendonitis when shoulder subluxation exceeds cut-off point*

Variables (cm)	β	SE	OR (95% CI)	*p*-value	R^2
Biceps tendonitis					
US LD ≥2.5	0.8	1.4	2.2 (0.1–31.1)	0.582	0.3
PE LD ≥2.25	1.8	1.3	5.9 (0.1–21.7)	0.168	1.9
X-ray LD ≥3.18	0.1	1.1	1.1 (0.6–31.2)	0.927	0.1
X-ray VD ≥3.08	2.4	1.1	11.5 (0.4–19.3)	0.020*	5.4
X-ray HD ≥2.65	1.5	1.1	4.6 (0.1–0.9)	0.149	2.1
Supraspinatus tendonitis					
US LD ≥2.5	0.5	1.5	1.6 (0.1~31.1)	0.749	1.1
PE LD ≥2.25	0.6	1.3	1.8 (0.1~21.7)	0.657	1.2
X-ray LD ≥3.18	1.5	1.0	4.4 (0.6~31.2)	0.139	2.2
X-ray VD ≥3.08	1.0	1.0	2.8 (0.4~19.3)	0.302	1.1
X-ray HD ≥2.65	2.2	1.0	9.1 (1.2~71.4)	0.034*	4.5

*$p<0.05$ by multi-variant backward logistic regression.
US LD: ultrasound lateral distance; PE LD: physical examination lateral distance; LD: lateral distance; VD; vertical distance; HD: horizontal distance; SE: standard error; CI: confidence interval; OR: odds ratio.

DISCUSSION

Post-hemiplegic shoulder subluxation commonly occurs during flaccidity after stroke (21). The basic pathology of shoulder subluxation involves the loss of centring of the humeral head within the glenoid fossa. This phenomenon is usually found in patients who have reduced functioning of the static stabilizers of the shoulder. In post-hemiplegic stroke patients, the humeral head is displaced inferiorly by a loss of normal shoulder muscle strength, especially in the supraspinatus, and deltoid muscles, and the weight of the upper limb stretches the soft tissue of the shoulder, resulting in subluxation (10). Lo et al. (4) mentioned that subluxation is one of the major factors contributing to shoulder pain in patients with hemiplegia. However, the correlation of shoulder pain with subluxation is controversial. Aras et al. (2) found that there was no correlation of shoulder subluxation with pain; using ultrasound they found more soft-tissue injuries in a group of stroke patients with shoulder pain. Barlak et al. (21) found that some patients had subluxation without pain, and that the most important causes of shoulder pain were adhesive capsulitis and complex regional pain syndrome-I (CRPS-I). They could not determine a correlation between the grade of subluxation and pain. In addition, they assumed that shoulder pain is caused mainly by periarticular tissue injury not merely by subluxation. In the course of rehabilitation, as hemiplegic shoulder pain can interfere with functional activities and rehabilitation programmes, prevention and appropriate management are required as early as possible (22). Soft-tissue injuries were more highly correlated with shoulder pain than with shoulder subluxation. However, screening for shoulder subluxation is more applicable than screening for soft-tissue injury, which requires ultrasound or magnetic resonance imaging (MRI) facilities. For the above reasons, we studied the correlation of shoulder subluxation and soft-tissue injuries and whether patient with more sever subluxation were more vulnerable to soft-tissue injuries.

Our results show that ultrasound revealed a higher percentage of tendonitis in hemiplegic shoulders than unaffected shoulder. The biceps and the supraspinatus tendons were major sites of soft-tissue injury and lesions. This result is compatible with those of the previous study by Huang et al. (7) (50% in biceps and 47.1% in supraspinatus tendon), who also found that acute stroke patients with poor upper limb motor function, combined with impaired sensation, shoulder spasticity and subluxation, have a higher prevalence of shoulder soft-tissue injuries (85%) and hemiplegic shoulder pain (67%). Lee et al. (3), studied stroke patients in 3 groups according to Brunnstrom stage. A lower frequency of soft-tissue injury was found in high motor function stage patients. However, there was no correlation between Brunnstrom stages and the severity grades of ultrasound findings. They concluded that the pathology of soft-tissue injury of the shoulder cannot be estimated merely by motor recovery stage, and that ultrasound is an essential method for evaluation of post-hemiplegic shoulder pain.

Correlation of shoulder subluxation and soft-tissue injuries has not been well studied previously. Huang et al. (7) found a higher frequency of subluxation and soft-tissue injuries among stroke patients with poor motor function. They found that more soft-tissue injuries occurred in the poor motor function group after admission to a rehabilitation programme. This may be attributed to poor protection of weakened shoulder girdle muscles. The mechanism of shoulder soft-tissue injuries is similar to that of subluxation, which is also more vulnerable happened under poor muscle strength of shoulder girdle. Therefore, we hypothesized that shoulder subluxation may be a predisposing factor for soft-tissue injuries.

In the evaluation of shoulder subluxation, a physical screening test is carried out prior to physical, radiographic and ultrasound examinations. Shoulder subluxation can be diagnosed by observation and surface palpation of the gap between the acromion and the humeral head (10). Lateral distance measurement was included in this study in order to compare subluxation measurement by ultrasound. However, this method lacks reliability and validity data. Several radiographic methods for evaluating shoulder subluxation have been reported previously. The method presented by Van Langenberghe & Hogan used a 5-point rating scale for radiographic evaluation (13). Although this evaluation is easily interpreted by the physician, additional studies have pointed out that the inter-rater reliability is low (23). As a result, we selected the method described by Brooke et al. for measurement of vertical and horizontal distance (19). Moreover, we measured the lateral distance in order directly to compare the results of the ultrasound and physical examinations. The vertical and horizontal dimensions measured by radiography for evaluation of subluxation were close to statistical significance as predictors for biceps and supraspinatus tendonitis, respectively. Shoulder subluxation lateral distance measured by physical examination was taken as a predictor for supraspinatus tendonitis (Table III). These results can be explained insofar as different tendon pathways may be comparable to different subluxation parameters.

In clinical practice it is especially important to determine whether the severity of shoulder subluxation measured by radiographic and physical examination necessitates further examination with more advanced ultrasound technology, as not all medical facilities have adequate training certification and suitable equipment for performing musculoskeletal ultrasound examination. Hence, it is useful to define the cut-off points of shoulder subluxation severity that indicate a need for further ultrasonography of soft-tissue injuries. Our data indicate that, for a stroke with biceps tendonitis, vertical distance assessed by radiography is more specific and has a higher positive and negative predictive value. For supraspinatus tendonitis, ultrasound has a higher negative predictive value, but lateral distance by radiography has a higher predictive value. In addition, this outcome is presented similarly by multivariate logistic regression, from which it can be seen that a vertical distance greater than the cut-off point indicates 11.5 times the risk for bicep tendonitis, and a horizontal distance that exceeds the cut-off point indicates 9.1 times the risk for supraspinatus tendonitis. We hypothesize that this outcome may be due to the different anatomical structure or orientation of the biceps and supraspinatus tendons.

There are 4 limitations to the present study. First, only a small number of patients was analysed, using limited validity and reliability methods for shoulder subluxation, without any gold-standard soft-tissue injury evaluation by MRI. This may lead to more bias in the outcome of this study. Secondly, only cross-sectional image evaluation was used to assess shoulder subluxation (by radiography and ultrasound) and soft-tissue injuries (by ultrasound). The correlation between severity of shoulder subluxation and the restoration of post-hemiplegic functional ability during rehabilitation was not investigated. Therefore, longitudinal follow-up studies are warranted. Thirdly, we did not evaluate the anterior measurement of the length from the anterior boarder of the acromion to the lesser tuberosity apex of the humeral bone. This is because the placement of the transducer did not allow for detection of this parameter in a single view, and this could result in measurement errors (18). Fourthly, when a single physiatrist evaluates shoulder subluxation and soft-tissue injury, potential bias may occur. Subdividing the ultrasound evaluation protocol into subluxation and soft-tissue injury parts, performed separately by two physiatrists, may help to prevent this bias in further studies.

In conclusion, evaluation of the severity of post-hemiplegic shoulder subluxation in stroke patients can be used as a reference for further examination of soft-tissue injury using ultrasound. Further ultrasound examination for soft-tissue injury is indicated when the parameters of shoulder subluxation distance are greater than the cut-off values by physical or radiograph examination. This is a valuable reference for use in clinical practice, especially for those medical facilities with limited ultrasound examination resources. Furthermore, ultrasound alone could be performed for both shoulder subluxation and soft-tissue injury provided the facility is adequately equipped for ultrasound examinations.

REFERENCES

1. Najenson T, Yacubovich E, Pikielni SS. Rotator cuff injury in shoulder joints of hemiplegic patients. Scand J Rehabil Med 1971; 3: 131–137.
2. Aras MD, Gokkaya NKO, Comert D, Kaya A, Cakci A. Shoulder pain in hemiplegia: results from a national rehabilitation hospital in Turkey. Am J Phys Med Rehabil 2004; 83: 713–719.
3. Lee IS, Shin YB, Moon TY, Jeong YJ, Song JW, Kim DH. Sonography of patients with hemiplegic shoulder pain after stroke: correlation with motor recovery stage. AJR Am J Roentgenol 2009; 192: W40–44.
4. Lo SF, Chen SY, Lin HC, Jim YF, Meng NH, Kao MJ. Arthrographic and clinical findings in patients with hemiplegic shoulder pain. Arch Phys Med Rehabil 2003; 84: 1786–1791.
5. Ikai T, Tei K, Yoshida K, Miyano S, Yonemoto K. Evaluation and treatment of shoulder subluxation in hemiplegia: relationship between subluxation and pain. Am J Phys Med Rehabil 1998; 77: 421–426.
6. Van Ouwenaller C, Laplace PM, Chantraine A. Painful shoulder in hemiplegia. Arch Phys Med Rehabil 1986; 67: 23–26.
7. Huang YC, Liang PJ, Pong YP, Leong CP, Tseng CH. physical findings and sonography of hemiplegic shoulder in patients after acute stroke during rehabilitation. J Rehabil Med 2010; 42: 21–26.
8. Culham EG, Noce RR, Bagg SD. Shoulder complex position and glenohumeral subluxation in hemiplegia. Arch Phys Med Rehabil 1995; 76: 857–864.
9. Kumar R, Metter EJ, Mehta AJ, Chew T. Shoulder pain in hemiplegia. The role of exercise. Am J Phys Med Rehabil 1990; 69: 205–208.
10. Boyd EA, Goudreau L, O'Riain MD, Grinnell DM, Torrance GM, Gaylard A. A radiological measure of shoulder subluxation in hemiplegia: its reliability and validity. Arch Phys Med Rehabil 1993; 74: 188–193.
11. Hayes KW, Sullivan JE. Reliability of a new device used to measure shoulder subluxation. Phys Ther 1989; 69: 762–767.
12. Prevost R, Arsenault AB, Dutil E, Drouin G. Shoulder subluxation in hemiplegia: a radiologic correlational study. Arch Phys Med Rehabil 1987; 68: 782–785.
13. Van Langenberghe HV, Hogan BM. Degree of pain and grade of subluxation in the painful hemiplegic shoulder. Scand J Rehabil Med 1988; 20: 161–166.
14. Paci M, Nannetti L, Rinaldi LA. Glenohumeral subluxation in hemiplegia: an overview. J Rehabil Res Dev 2005; 42: 557–568.
15. Park GY, Kim JM, Sohn SI, Shin IH, Lee MY. Ultrasonographic measurement of shoulder subluxation in patients with post-stroke hemiplegia. J Rehabil Med 2007; 39: 526–530.
16. Kumar P, Bradley M, Gray S, Swinkels A. Reliability and validity of ultrasonographic measurements of acromion-greater tuberosity distance in poststroke hemiplegia. Arch Phys Med Rehabil 2011; 92: 731–736.
17. Pong YP, Wang LY, Wang L, Leong CP, Huang YC, Chen YK. Sonography of the shoulder in hemiplegic patients undergoing rehabilitation after a recent strore. J Clin Ultrasound 2009; 37: 199–205.
18. Gregson JM, Leathley M, Moore AP, Sharma AK, Smith TL, Watkins CL. Reliability of the Tone Assessment Scale and the modified Ashworth scale as clinical tools for assessing poststroke spasticity. Arch Phys Med Rehabil 1999; 80: 1013–1016.
19. Brooke MM, de Lateur BJ, Diana-Rigby GC, Questad KA. Shoulder subluxation in hemiplegia: effects of three different supports. Arch Phys Med Rehabil 1991; 72: 582–586.
20. Middleton WD. Ultrasonography of the shoulder. Radiol Clin North Am 1992; 30: 927–940.
21. Barlak A, Unsal S, Kaya K, Sahin-Onat S, Ozel S. Poststroke shoulder pain in Turkish stroke patients: relationship with clinical factors and functional outcomes. Int J Rehabil Res 2009; 32: 309–315.
22. Roy C, Sands M, Hill L. Shoulder pain in acutely admitted hemiplegics. Clin Rehabil 1994; 8: 334–340.
23. Snels IA, Beckerman H, ten Kate JJ, Lankhorst GJ, Bouter LM. Measuring subluxation of the hemiplegic shoulder: reliability of a method. Neurorehabil Neural Repair 2001; 15: 249–254.