Study On The Pathogenesis Of Post-Stroke Shoulder Pain Based On The Characteristics Of Magnetic Resonance Imaging-A Retrospective Study

Studie zur Pathogenese von Schulterschmerzen nach Schlaganfall anhand charakteristischer MRT-Merkmale: eine retrospektive Studie

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ABSTRACT

Background High morbidity has been proved frequently happened in post-stroke shoulder pain (PSSP), but the specific pathogenesis of PSSP still remains unclear. Therefore, further research needs to be done to investigate this field.

Objective The aim of this study which reviewed the features of magnetic resonance imaging (MRI) on shoulder joint of patients with PSSP, is to find the consequence of pathogenesis.

Methods This study starts from June 2017 to August 2021, 74 PSSP patients who accepted MRI examination were selected in the Department of rehabilitation medicine of the Second Affiliated Hospital of Nanjing Medical University (inpatient and outpatient). This study sorted out and summarized patients' MRI characteristics, analyzing differences of MRI appearance according to age, gender, hemiplegic side, stroke type and onset time.

Results After examining all PSSP patients' MRI characteristics, this study found 56 (75.67 %) had supraspinatus tendon injury, 11 (14.86 %) infraspinatus tendon injury, 24 (32.43 %) subscapular tendon injury, 2 (2.7 %) teres minor tendon injury, 60 (81.08 %) tendon sheath effusion (inflammation) of long head of biceps brachii, 23 (31.08 %) humeral head bone marrow edema and 64 (86.49 %) shoulder joint capsule effusion. Moreover, there were 6 cases of acromial descending sac effusion (8.11 %), 11 cases of coracoid descending sac effusion (14.86 %), 8 cases of synovial thickening (10.81 %), and 1 case of ossifying myositis (1.35 %).

Conclusion No significant differences were found in MRI features according to gender and hemiplegic side .The results showed the injury of supraspinatus tendon significantly increased in the older group compared to the younger group (P = 0.039).The patients with supraspinatus tendon injury and tendon sheath effusion (inflammation) of long head of biceps brachii have higher cerebral infarction than patients with cerebral hemorrhage (P = 0.002, P = 0.028). Based on the time of onset, the participants were divided into three groups: within 1 month, 1–3 months and more than 3 months. The results suggested significant differences in humeral head bone marrow edema and shoulder joint capsule effusion numbers among the three groups (P = 0.049, P = 0.002). The results of this research could help to improve the accuracy of clinical diagnosis and treatment of PSSP, putting forward a more reasonable treatment scheme.

ZUSAMMENFASSUNG

Hintergrund Es hat sich gezeigt, dass Schulterschmerzen nach Schlaganfall häufig mit hoher Morbidität einhergehen, doch ist die genaue Pathogenese noch nicht geklärt. Daher sind weiteren Studien in diesem Bereich erforderlich.

Ziel Ziel der vorliegenden Studie war es, durch die Untersuchung der Auffälligkeiten in der Magnetresonanztomographie (MRT) des Schultergelenks bei Patienten mit Schulterschmerzen nach Schlaganfall die sich aus der Pathogenese ergebenden Folgezustände zu ermitteln.

Methodik Im Rahmen der Studie wurden in der Abteilung für Rehabilitationsmedizin des zweiten angegliederten Krankenhauses der Medizinischen Universität Nanjing 74 (stationäre oder ambulante) Patienten mit Schulterschmerzen nach Schlaganfall, die zwischen Juni 2017und August 2021 einer MRT-Untersuchung zugestimmt hatten, ausgewählt. In der Studie wurden die MRT-Merkmale der Patienten ermittelt und zusammengefasst. MRT-Auffälligkeiten wurden nach Alter, Geschlecht, Seite der Hemiplegie, Schlaganfalltyp und Zeitpunkt des Auftretens analysiert.

Ergebnisse Nach Untersuchung der MRT-Veränderungen bei allen in die Studie aufgenommenen Patienten mit Schulterschmerzen nach Schlaganfall ergab sich folgende Verteilung: 56 (75, 67 %) Patienten mit Verletzung der Supraspinatussehne, 11 (14, 86 %) mit Verletzung der Infraspinatussehne, 24 (32, 43 %) mit Verletzung der Subscapularissehne, 2 (2, 7 %) mit Verletzung der Sehne des Musculus teres minor, 60 (81, 08 %) mit Sehnenscheidenerguss (Entzündung) der Sehne des Caput longum des Musculus biceps brachii, 23 (31, 08 %) mit Knochenmarködem im Bereich des Humeruskopfes und 64 (86, 49 %) mit Erguss der Schultergelenkskapsel. Darüber hinaus gab es 6 Fälle mit Erguss der Bursa subakromialis (8, 11 %), 11 Fälle mit Erguss der Bursa subcoracoidea (14, 86 %), 8 Fälle mit Verdickung der Synovia (10, 81 %) und 1 Fall mit Myositis ossificans (1, 35 %).

Schlussfolgerung Es fanden sich keine signifikanten Unterschiede in den MRT-Merkmalen in Bezug auf das Geschlecht und die Seite der Hemiplegie. Die Ergebnisse zeigten, eine signifikante Zunahme der Verletzung der Supraspinatussehne in der Gruppe der älteren Patienten im Vergleich zur Gruppe der jüngeren Patienten (P = 0, 039). *Bei Patienten mit einer Verletzung der Supraspinatussehne und einem Sehnenscheidenerguss (Entzündung) der Sehne des Caput longum des M. biceps brachii liegt häufiger ein Hirninfarkt vor als eine Hirnblutung (P = 0, 002, P = 0, 028).* Je nach Zeitpunkt des Auftretens wurden die Teilnehmer in drei Gruppen eingeteilt: innerhalb von 1 Monat, 1–3 Monaten und mehr als 3 Monaten.

Die Ergebnisse weisen auf signifikante Unterschiede in der Anzahl der Knochenmarködeme des Humeruskopfes und der Ergüsse der Schultergelenkkapsel zwischen den drei Gruppen hin (P = 0, 049, P = 0, 002). Die Ergebnisse dieser Untersuchung könnten dazu beitragen, die Genauigkeit der klinischen Diagnose und Therapie von Patienten mit Schulterschmerzen nach Schlaganfall zu verbessern und ein sinnvolleres Behandlungsschema zu entwickeln.

Post-stroke shoulder pain (PSSP), also known as hemiplegic shoulder pain (HSP), becomes a manifestation of pain in hemiplegic shoulder joints after stroke. PSSP is one of the most common complications of stroke [1]. The high incidence rate of PSSP (16–84 %) has greatly affected rehabilitation training on the upper limb [2]. It not only increases the rehabilitation time and expenditure of people with stroke, but also linking with post-stroke depression and anxiety (as a main pathogeny) [3–5]. In addition, a small number of PSSP patients have resting pain, which easily leads to insomnia, further increases anxiety and form a vicious circle.

At present, there were many clinical treatment methods for PSSP, mainly including health education , non-steroid anti-inflammatory drug, exercise therapy, percutaneous electrical stimulation, transcranial magnetic stimulation, botulinum toxin injection, steroid injection, intramuscular patch, acupuncture and traditional massage, which effectively alleviate pain and even improve limb function [6].The various treatments above are based on the previous scholars' research on the mechanism of PSSP. Currently, it is considered that the pathogenesis of PSSP consists of shoulder subluxation, joint capsule adhesion, rotator cuff injury, abnormal muscle tension, joint contracture, central pain, reflex sympathetic dystrophy, etc [7, 8]. There are no relevant researches on the primary and secondary relationship of pathogenesis, which may also be the consequence for being lack of PSSP related guidelines and consensus. In order to further understand the pathogenesis of PSSP and clarify the most common causes of PSSP, the study reviewed the magnetic resonance imaging (MRI) of 74 patients with PSSP in the inpatient and outpatient department of rehabilitation medicine of the Second Affiliated Hospital of Nanjing Medical University from June 2017 to August 2021, summarizing the MRI characteristics and hoping to find the most common and major causes of PSSP as well as providing clinical evidence for PSSP treatment.

Methods

Eligibility Criteria

Review the magnetic resonance imaging of 74 patients with PSSP in the inpatient and outpatient department of rehabilitation medicine of the Second Affiliated Hospital of Nanjing Medical University from June 2017 to August 202. In this study, 94 patients were preliminarily collected, and a total of 74 patients were enrolled according to inclusion and exclusion criteria. Patient inclusion criteria:1.Meet the diagnostic criteria for stroke revised by the 4th National Academic Conference on cerebrovascular diseases [9], first stroke (cerebral infarction or intracerebral hemorrhage) which is confirmed by cranial CT or MRI; 2.Unilateral limb paralysis; 3.Meet PSSP diagnostic criteria: emiplegic side shoulder joint pain happens after stroke. These include spontaneous shoulder pain or shoulder pain induced by passive motion within the range of motion of the shoulder joint [10]; 4.Active and passive motion pain or resting pain of hemiplegic shoulder joint; 5.No shoulder pain before stroke; 6.There was no pain caused by shoulder fracture after stroke;7. Complete clinical data.

Study design

The data of PSSP patients (gender, age, stroke type, onset time, pain degree, Brunnstrom evaluation stage and magnetic resonance imaging characteristics etc.) were retrospectively analyzed. Pain degree adopted visual analogue scale (VAS) [11], Brunnstrom evaluation [12]: Stage I, when no voluntary movement of the affected limb can be initiated; Stage II, The basic limb synergies or some of their components now make their appearance either as weak associated reactions or on voluntary attempt to move by the patient; Stage III, The basic limb synergies or some of their components are performed voluntarily and are sufficiently developed to show definite joint movements; Stage IV, spasticity decreases, and an increasing number of movement combinations which deviate from the basic limb synergies become possible; Stage V, A relative independence of the basic limb synergies characterizes this stage, and spasticity is waning; Stage VI, Isolated joint movements are now freely performed;1.5 T magnetic resonance scanner produced by GE company in the United States was used for MRI examination. The patients were measured in a supine position, the upper limb on the affected side in the straight position, the palm was placed outside of the ipsilateral thigh, and the special shoulder coil was used for examination. Plain scan includes axial, oblique sagittal and oblique coronal fat suppression FSE proton density weighted imaging (PDWI) sequences. Specific parameters: oblique coronal fat suppression T2 weighted imaging (TR/te2700–3700ms/64–73ms; echo column length 1–16; section thickness 3 mm; matrix 480 × 480; field of view 14–15 cm). Oblique coronal intermediate weighted imaging (TR/te2300–3300ms/25–30ms; echo column length 7–8; section thickness 2.5–3 mm; matrix 512) × 512; field of view (14 cm). Oblique sagittal fat suppression T2 weighted imaging (TR/te3200–4300ms/7290ms; echo column length 12–18; section thickness 2.5–3 mm; matrix 512) × 512; field of vision 14 cm). The shoulder MRI of PSSP patients was completed by two senior doctors in the imaging department, and the MRI results were released after being confirmed by the third imaging doctor. Clinical rehabilitation outcomes were also evaluated.

▶ Table 1 General situation and MRI features of patients

Clinical data	Number (%)
Number of cases	74
Male	45 (60.81 %)
Female	29 (39.19 %)
Age (years)	64.50 ± 11.35
Hemiplegia side	
Left	42 (56.76 %)
Right	32 (43.24 %)
Stroke type	
Cerebral infarction	50 (67.57 %)
Cerebral hemorrhage	24 (32.43 %)
Shoulder pain degree (VAS)	4.27 ± 0.96
Onset time of shoulder pain after stroke (month	3.05 ± 2.77
after stroke (month)	
Brunnstrom evaluation period	
I	3 (4.05 %)
II	25 (33.78 %)
III	17 (22.97 %)
IV	22 (29.73 %)
V	7 (9.47 %)
Rotator cuff injury	
Supraspinatus	56 (75.67 %)
Infraspinatus	11 (14.86 %)
Subscapularis	24 (32.43 %)
Teres minor	2 (2.7 %)
Biceps brachii long head	60 (81.08 %)
tendon sheath effusion	
Humeral head bone marrow edema	23 (31.08 %)
Edema	
Shoulder capsular effusion	64 (86.49 %)
Acromial descent capsule effusion	6 (8.11 %)
Coracoid descent capsule effusion	11 (14.86 %)
Synovial thickening	8 (10.81 %)
Myositis ossificans	1 (1.35 %)

Statistical analysis

SPSS 25.0 software was used to analyze the data. Chi square test was performed by age, gender, hemiplegic side and stroke type. Comparisons between groups were conducted using Pearson's chi-squared test, continuity correction chi-squared test or Fisher's exact probability test. Using Kruskal-Wallis test for the time of shoulder pain after stroke. The statistically significant MRI features analyzed by chi square test and rank sum test were selected for further correlation analysis.

▶ **Table 2** Analysis of MRI features by age group

MRI features	Age (number)		Sum	X2	P value
	≦65years 42	>65years 32			
Supraspinatus	28 (66.67 %)	28 (87.50 %)	56	4.282	0.039 [a]
Infraspinatus	5 (11.90 %)	6 (18.75 %)	11	0.672	0.412 [a]
Subscapularis	14 (33.34 %)	10 (31.25 %)	24	0.036	0.850 [a]
Teres minor	0 (0.00 %)	2 (6.25 %)	2		0.184 [c]
Biceps brachii long head tendon effusion	34 (80.95 %)	26 (81.25 %)	60	0.001	0.974 [a]
Humeral head bone marrow edema	12 (28.57 %)	11 (34.37 %)	23	0.286	0.593 [a]
Shoulder capsular effusion	35 (83.34 %)	29 (90.62 %)	64	0.320	0.572 [a]
Acromial descent capsule effusion	4 (9.52 %)	2 (6.25 %)	6	0.007	0.935 [b]
Coracoid descent capsule effusion	8 (25.00 %)	3 (9.37 %)	11	0.687	0.407 [b]
Synovial thickening	5 (11.90 %)	3 (9.37 %)	8	0.000	1.000 [b]
Myositis ossificans	1 (2.38 %)	0 (0.00 %)	1		1.000 [c]

a is Pearson's chi-squared test; b is continuity correction chi-squared test; c is Fisher's exact probability test

Results

▶ **Table 1** presents the summary statistics for PSSP. A total of 74 patients met the inclusion criteria, including 45 males and 29 females, with average age of 64.50 ± 11.35 years (age range:37–89 years). Among them, 42 patients had left hemiplegia, 32 patients with right hemiplegia, 50 patients with cerebral infarction, 24 patients with cerebral hemorrhage. VAS score of enrolled patients was 4.27 ± 0.96 points.The time between the onset of shoulder pain and stroke was 3.05 ± 2.77 months. By the Brunnstrom evaluation standard of the affected upper limb, 3, 25, 17, 22, 7 patients were divided into I-V stage respectively. MRI features showed 56 patients with supraspinatus injury (75.67 %), 11 patients with infraspinatus injury (14.86 %), 24 patients with subscapularis injury (32.43 %), 2 patients with teres minor injury (2.7 %), 60 patients with biceps longus tendon sheath effusion (81.08 %). There were 23 patients with humerus head bone marrow edema (31.08 %). 64 shoulder capsular effusion (86.49 %), 6 acromial descent capsular effusion (8.11 %), 11 coracoid descent capsular effusion (14.86 %), 8 synovial thickening (10.81 %) and 1 myositis ossificans (1.35 %).

In ▶ **Table 2**, It is generally confirmed that people over 65 years old are the elderly [13, 14] and the average age of the overall sample size is 64.5 years old. Therefore, 65 years old is divided into two groups all patients were divided into two groups by their average age (65 years old), and MRI characteristics between the two groups were statistically analyzed by Chi-square test. The test results showed that the incidence of tendon injury of the Supraspinatus muscle was higher in older PSSP patients (> 65 years old) than in younger patients, and the difference was statistically significant. There was no significant correlation between age and other shoulder MRI features. The difference was not statistically significant.

In ▶ **Table 3**, all patients were divided into two groups according to gender, and MRI characteristics between the two groups were statistically analyzed. The test results showed that MRI characteristics of shoulder joint in PSSP patients were not correlated with gender, and the difference was not statistically significant.

In ▶ **Table 4**, all patients were divided into two groups according to hemiplegia side, and MRI characteristics between the two groups were analyzed. The test results showed that there was no correlation between MRI characteristics of shoulder joint in PSSP patients and hemiplegia.

In ▶ **Table 5**, all patients can be divided into two groups according to the type of stroke. MRI characteristics between the two groups were analyzed. The test results showed patients with cerebral hemorrhage had higher incidence of supraspinatus tendon injuries and biceps long head tendon sheath effusion compared to cerebral infarction patients. The difference was statistically significant.

In ▶ **Table 6**, PSSP events were divided into three groups based on post-stroke shoulder pain time: the acute period (within 1 month), the subacute period (1–3 months), the sequela period (3 months above). MRI characteristics between the three groups were analyzed by Kruskal-Wallis test. The test results showed that the humerus head marrow edema and shoulder joint capsule effusion were correlated with post-stroke shoulder pain time.

Discussion

PSSP is one of the common complications after stroke. Long-term pain not only affects rehabilitation treatment but also further aggravates patients' pessimism. However, the pathogenesis of PSSP is still not very clear , and it is believed that it may be related to soft tissue injury, motor control disorder, peripheral and central nervous system lesions, and other factors, among which local soft tissue injury is often considered as the most direct cause of PSSP [15]. Shoulder joint is a basic ball and socket joint, which can be rotated in three mutually vertical axis of motion in all directions, in order to maintain the stability of the joint and the maximum range of motion, there are more muscles, tendons, joint capsule and other

▶ **Table 3** MRI features were analyzed by gender grouping

MRI features	Sum	gender (number)		X^2	P value
		Male n = 45	Female n = 29		
Supraspinatus	56	33 (73.33 %)	23 (79.31 %)	0.342	0.559 [a]
Infraspinatus	11	4 (8.89 %)	7 (24.14 %)	2.147	0.143 [b]
Subscapularis	24	11 (24.44 %)	13 (44.83 %)	3.344	0.067 [a]
Teres minor	2	1 (2.22 %)	1 (3.45 %)	0.000	1.000 [b]
Biceps brachii long head tendon effusion	60	35 (77.78 %)	25 (86.20 %)	0.360	0.549 [a]
Humeral head bone marrow edema	23	14 (31.11 %)	9 (31.03 %)	0.000	0.994 [a]
Shoulder capsular effusion	64	38 (84.44 %)	26 (89.66 %)	0.085	0.770 [a]
Acromial descent capsule effusion	6	4 (8.89 %)	2 (6.90 %)	0.000	1.000 [b]
Coracoid descent capsule effusion	11	6 (13.33 %)	5 (17.24 %)	0.213	0.645 [a]
Synovial thickening	8	5 (11.11 %)	3 (10.34 %)	0.000	1.000 [b]
Myositis ossificans	1	1 (2.22 %)	0 (0.00 %)		1.000 [c]

a is Pearson's chi-squared test; b is continuity correction chi-squared test; c is Fisher's exact probability test

▶ **Table 4** MRI features were analyzed by grouping according to hemiplegia side

MRI features	Sum	Hemiplegia side (number)		X^2	P value
		Left n = 42	Right n = 32		
Supraspinatus	56	33 (78.57 %)	23 (71.87 %)	0.442	0.506 [a]
Infraspinatus	11	7 (16.67 %)	4 (12.50 %)	0.029	0.866 [b]
Subscapularis	24	13 (30.95 %)	11 (34.38 %)	0.097	0.755 [a]
Teres minor	2	0 (0.00 %)	2 (6.25 %)		0.177 [c]
Biceps brachii long head tendon effusion	60	34 (80.95 %)	26 (81.25 %)	0.001	0.974 [a]
Humeral head bone marrow edema	23	11 (26.19 %)	12 (37.50 %)	1.084	0.298 [a]
Shoulder capsular effusion	64	37 (88.10 %)	27 (84.38 %)	0.215	0.643 [a]
Acromial descent capsule effusion	6	3 (7.14 %)	3 (9.38 %)	0.000	1.000 [b]
Coracoid descent capsule effusion	11	5 (11.90 %)	6 (18.75 %)	0.672	0.412 [a]
Synovial thickening	8	6 (14.29 %)	2 (6.25 %)	0.526	0.468 [b]
Myositis ossificans	1	0 (0.00 %)	1 (3.13 %)		0.432 [c]

a is Pearson's chi-squared test; b is continuity correction chi-squared test; c is Fisher's exact probability test

soft tissue around the shoulder joint need to coordinate work. As the consequence of decreased muscle strength, decreased or increased muscle tension on the affected side after stroke, as well as the injury of soft tissue around the shoulder caused by wrong limb placement and excessive wrong limb pulling, the identification of the specific soft tissue injury is the key to the treatment of PSSP. Currently, musculoskeletal ultrasound and MRI were the most widely used examination methods in clinical practice. Due to the complexity of shoulder anatomical structure and the limitations of ultrasound penetration, MRI is generally considered to be more specific and sensitive than musculoskeletal ultrasound in the examination of shoulder which is considered to be the most reliable examination technology at present [16]. Based on MRI examination method, the study reviewed the MRI characteristics of PSSP patients in the past 4 years and tried to find and explore the correlation between shoulder pain incidence and age, gender, hemiplegia, stroke type, onset time and other aspects.

The study found that the top three injuries incidence of PSSP patients were shoulder capsule effusion (64 patients), biceps long cephalic tendon effusion (inflammation) (60 patients), and supraspinatus tendon injury in (56 patients), accounting for 86.49 %, 81.08 %, and 75.67 %, respectively. The results of this study were

▶ **Table 5** MRI features were grouped according to stroke types

MRI features	Sum	Stroke type (number)		X²	P value
		Cerebral infarction n = 50	Cerebral hemorrhage n = 24		
Supraspinatus	56	42 (84.00 %)	12 (50.00 %)	9.505	0.002 [a]
Infraspinatus	11	7 (14.00 %)	4 (16.67 %)	0.000	1.000 [b]
Subscapularis	24	20 (40.00 %)	4 (16.67 %)	3.034	0.082 [b]
Teres minor	2	1 (2.00 %)	1 (4.16 %)	0.000	1.000 [b]
Biceps brachii long head tendon effusion	60	44 (88.00 %)	16 (66.67 %)	4.881	0.028 [a]
Humeral head bone marrow edema	23	15 (30.00 %)	8 (33.34 %)	0.084	0.772 [a]
Shoulder capsular effusion	64	46 (92.00 %)	18 (85.71 %)	2.687	0.101 [a]
Acromial descent capsule effusion	6	5 (10.00 %)	1 (4.16 %)	0.165	0.685 [b]
Coracoid descent capsule effusion	11	6 (12.00 %)	5 (20.83 %)	1.000	0.317 [a]
Synovial thickening	8	5 (10.00 %)	3 (12.5 %)	0.000	1.000 [a]
Myositis ossificans	1	0 (0.00 %)	1 (4.16 %)		0.329 [c]

a is Pearson's chi-squared test; b is continuity correction chi-squared test; c is Fisher's exact probability test

▶ **Table 6** MRI features were grouped according to post-stroke shoulder pain time

MRI features	Sum	post-stroke shoulder pain time (number)			Z	P value
		t≦1month n = 25	1 month < t ≦ 3months n = 30	t > 3 months n = 19		
Supraspinatus	56	17 (68.00 %)	27 (90.00 %)	12 (63.16 %)	−0.074	0.941
Infraspinatus	11	1 (4.00 %)	10 (33.33 %)	0 (0.00 %)	−0.089	0.929
Subscapularis	24	9 (36.00 %)	10 (33.33 %)	5 (26.32 %)	−0.653	0.514
Teres minor	2	1 (4.00 %)	1 (3.33 %)	0 (0.00 %)	−0.765	0.444
Biceps brachii long head tendon effusion	60	18 (72.00 %)	28 (93.33 %)	14 (73.68 %)	−0.412	0.680
Humeral head bone marrow edema	23	3 (12.00 %)	13 (43.33 %)	7 (36.84 %)	−1.969	0.049
Shoulder capsular effusion	64	23 (92.00 %)	27 (90.00 %)	14 (73.68 %)	−3.056	0.002
Acromial descent capsule effusion	6	0 (0.00 %)	4 (13.33 %)	2 (10.52 %)	-1.416	0.157
Coracoid descent capsule effusion	11	5 (20.00 %)	3 (10.00 %)	3 (15.79 %)	−0.503	0.615
Synovial thickening	8	2 (8.00 %)	4 (13.33 %)	2 (10.52 %)	−0.334	0.738
Myositis ossificans	1	0 (0.00 %)	0 (0.00 %)	1 (5.26 %)	−1.374	0.169

consistent with previous domestic and foreign research results [17, 18]. Therefore, joint capsule effusion, biceps long Cephalus tendon sheath effusion (inflammation) and supraspinatus tendon injury are the most common MRI features of shoulder in patients with PSSP.

The average age of onset of PSSP patients was 66.52 years [17], the results were basically the same as this study. There were few age-related studies on PSSP patients at home and abroad. This study also showed that patients older than 65 years of age with PSSP had a greater chance of supraspinatus muscle injury. Supraspinatus muscle is one of the rotator cuff muscles, which plays a significant role in shoulder joint abduction and anti-gravity to maintain the humeral head in the right position. After stroke, supraspinatus muscle congestion, injury and even tear due to decreased muscle strength, gravity pulling, inappropriate passive activity, shoulder dislocation and loss of nutritional support. Supraspinatus muscle injury is one of the important causes of PSSP [19]. This study demonstrated that the injury of supraspinatus muscle in the older patient's group and the younger patients group increased significantly, and the specific mechanism is not very clear. Reports find that the injury of supraspinatus muscle in the group without shoulder pain over 60 years old accounted for 30 % of the total, and the injury of supraspinatus muscle in the group without shoulder pain over 70 years old accounted for 65 % of the total [20]. In this study, the author considered the injury of the supraspinatus muscle in the elderly patients was significantly higher than that in the younger patients, which might be related to this, suggesting that more attention should be paid to the protection and treatment intervention of the supraspinatus muscle in the elderly patients with PSSP.

In this study, gender and hemiplegic group comparison demonstrated minimum significant difference, suggesting that the two consequences are not one of the causes of PSSP, which is consistent with recent research results [21]. According to the nature of stroke, patients were divided into cerebral infarction group and cerebral hemorrhage group to compare the MRI characteristics of the two groups. The results indicated that there was a difference in shoulder soft tissue injury between patients with cerebral infarction and patients with cerebral hemorrhage with PSSP. Refer to cases and analysis, the cause of the differences may be associated with different initial stroke care personnel. Patients with cerebral infarction were mostly taken care of by family members in the early time while cerebral hemorrhage patients mostly taken care of by a nurse or experienced nursing worker. Nurse or experienced nursing worker may do better job in putting in a good limb position and avoiding the wrong body pull.

The onset time span of PSSP is long, including 72 hours to several years after the stroke event, most of which occurred in 2–3 months after stroke [22]. The average onset time of shoulder pain in patients in this study was 3.05 months after stroke, basically consistent with previous studies. According to the onset time, patients were divided into three groups within 1 month, 1–3 months and more than 3 months, and MRI characteristics of patients in the three groups were compared. The results showed that there were significant differences in humeral head bone marrow edema and shoulder capsule effusion in the three groups. Bone marrow edema is a common clinical pathological change, which is mainly manifested by abnormal subchondral perfusion, ischemia and hypoxia of some tissues and infiltration of inflammatory cells [23]. Bone marrow edema can be divided into ischemic, mechanical and reactive (postoperative edema, osteoarthritis or tumor) according to pathogenesis [24]. Bone marrow edema of the humerus head is common in athletes engaged in throwing activities, but not common in the general population [25]. In this study, nearly 1/3 of PSSP patients showed bone marrow edema of the humerus, which was considered to be related to ischemia [26] or mechanical injury [17] caused by reduced blood supply to the shoulder joint after stroke. Bone marrow edema leads to increased intraosseous pressure and stimulates bone pain receptors in bone marrow, causing pain [27]. This study demonstrates that stroke events than 1 months after 1 month of shoulder pain, the participation of more bone marrow edema, also meet with blood reduce side shoulder joint, mechanical injury takes time to lead to bone marrow edema, in stroke events occurring after 1 month of shoulder pain, need to focus on treatment of bone marrow edema pain relief. Shoulder cyst effusion is one of the most common manifestations of PSSP. Lin [17] and Yu [28] confirmed the high incidence of shoulder cyst effusion in PSSP patients through ultrasound examination and MRI examination respectively. However, clinical attention has not been paid to the shoulder pain for many years is something worth to patients to reflect. Normal shoulder joint capsule has a small amount of liquid, lubricating joints and protect joints, joint capsule in fluid volume increase often prompts some reason causing cartilage synovial liquid layer secretion increased, and the absorption rate imbalances and joint cavity, and excessive fluid may increase the strength of shoulder pain [29], articular effusion treatment should be a starting point for the treatment of PSSP. In this study, it was found that the cell phone sac effusion of patients with shoulder pain starting within 3 months after the stroke event was significantly higher than that of patients who developed the disease after 3 months, which may be related to early acromial impingement and wrong upper limb pulling. Other factors cannot be excluded, and biochemical examination of joint cavity effusion can be performed when necessary to further clarify the cause of the disease.

From what has been discussed above some reasonable conclusion can be safely drawn that this study demonstrated PSSP patients had a wide range of shoulder soft tissue injuries, with shoulder capsule effusion, biceps long cephalic tendon sheath effusion (inflammation) and supraspinatus tendon injury being the most common. Supraspinatus tendon injury was more common in older PSSP patients than in younger patients. Moreover, the injury of supraspinatus tendon, hydrocele of long head tendon of biceps brachii and hydrocele of shoulder joint capsule were more common in PSSP patients with cerebral infarction than in patients with cerebral hemorrhage. In addition, there was a correlation between the incidence of humeral head bone marrow edema and the onset time of PSSP. The research results above could help to improve the accuracy of clinical diagnosis and treatment as well as the accuracy of diagnosis and treatment of PSSP, especially in primary medical institutions without MRI or musculoskeletal ultrasound and provide more accurate and reasonable treatment plan.

Shortcomings of this study: 1. The sample size was relatively small which may lead to bias in results; 2. The study scope was single-center. Although the interpretation of shoulder joint MRI was jointly decided by two radiologists, there were still omissions that could not point out the interpretation results of each other due to their similar work experience.

Conclusions

Shoulder joint capsule effusion, tendon sheath effusion (inflammation) of biceps brachii longus and supraspinatus tendon injury were the three most common features in PSSP patients' MRI. The injury of supraspinatus tendon in elderly patients happens more frequently than young patients; The incidence rate of supraspinatus tendon injury, scapular injury, biceps head tendon sheath hydrops and shoulder joint effusion were higher in cerebral infarction patients compared to cerebral hemorrhage patients. Humeral head bone marrow edema and effusion of shoulder joint capsule have a strong relevance to the onset time of shoulder pain. The results of this research could help to improve the accuracy of clinical diagnosis and PSSP treatment, putting forward a more reasonable treatment scheme.

Conflict of Interest

The authors declare that they have no conflict of interest.

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