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Original Article

Arthroscopic treatment for rotator cuff injury and frozen shoulder with concomitant rotator cuff injury: analysis of efficacy and factors influencing prognosis

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Abstract: Objective: To analyze the efficacy of arthroscopic treatment for patients with rotator cuff injuries and frozen shoulder combined with rotator cuff injuries and assess the factors influencing patient prognosis. Methods: A retrospective analysis was performed on 85 patients who underwent arthroscopic surgery at Hanzhong Central Hospital between October 2016 and October 2021, including 42 patients treated for rotator cuff injuries alone (Group A), and 43 patients for frozen shoulder combined with rotator cuff injuries (Group B). Both groups underwent general anesthesia with controlled hypotension during surgery. Treatment outcomes, including shoulder joint functional scores, pain scores, shoulder joint range of motion, and muscle strength were assessed and compared between the two groups before treatment, as well as at 2 weeks and 2 months post-treatment. Quality of life was also evaluated and compared at 2 months post-treatment. Patients were categorized into good and poor prognosis groups based on their outcome, and factors influencing patient prognosis were analyzed. Results: Before treatment, both groups exhibited relatively low shoulder joint function scores and external rotation angles, coupled with higher pain scores; however, these differences were not significant between groups (all $P>0.05$). The surgery duration for Group B was notably longer than that of Group A ($P<0.05$). Nevertheless, there was no significant variance in intraoperative blood loss between the two groups ($P>0.05$). After a 2-week treatment duration, both groups demonstrated a significant improvement in shoulder joint function score, pain score, and shoulder joint range of motion compared to baseline, but with no statistically significant intergroup differences. However, two months after the treatment, patients in Group A exhibited marked improvements in shoulder joint function score, pain score, shoulder joint range of motion, and overall quality of life compared to Group B (all $P<0.05$). Furthermore, the therapeutic efficacy in Group A was superior to that in Group B at the 2-month follow-up ($P<0.05$). Age, comorbid diabetes, metabolic disorders such as thyroid dysfunction, and the extent of shoulder cuff injury were identified as independent risk factors influencing prognosis. Conclusion: Arthroscopic treatment is effective for both frozen shoulder combined with rotator cuff injury and rotator cuff injury alone, with better outcomes observed in patients with rotator cuff injury only. This technique warrants further promotion.

Keywords: Arthroscopic surgery, rotator cuff injuries, frozen shoulder, prognosis

Introduction

The rotator cuff comprises the tendons from the subscapularis, supraspinatus, infraspinatus, and teres minor muscles. Rotator cuff injury, resulting from damage to these tendons, is commonly associated with activities such as lifting heavy objects, wrestling, and repetitive motions involving extreme external rotation of the shoulder [1, 2]. Such injuries predominantly affect middle-aged and elderly individuals, with high incidence in this demographic. Symptoms typically manifest as shoulder joint pain and restricted mobility, significantly affecting the quality of life [3, 4]. Most patients with rotator cuff injury lack a clear trauma history, and the injury may coincide with frozen shoulder. About 27%-34% of rotator cuff injury patients may additionally develop frozen shoulder [5]. Whether occurring independently or in conjunction with frozen shoulder, the absence of prompt intervention and treatment can significantly degrade the patient's quality of life.

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In clinical practice, diverse strategies are employed for the management of rotator cuff injuries, including acute-phase intervention, pharmacological treatment, open surgical procedures, and arthroscopic surgery. Arthroscopic surgery, recognized for its favorable therapeutic outcome, is the preferred approach [6]. However, it is primarily applied in cases of isolated rotator cuff injury [7]. The effectiveness of this treatment modality in addressing joint capsule adhesions in patients with concurrent frozen shoulder remains uncertain. With the ongoing advancement of minimally invasive techniques, arthroscopic technology continues to evolve, markedly enhancing its utility in managing rotator cuff injury [8]. Nevertheless, there is currently a dearth of research comparing the efficacy of arthroscopic surgery in treating patients with concurrent rotator cuff injury and frozen shoulder.

In order to further analyze the broad applicability of arthroscopic surgery in patients with rotator cuff injury, we compared its therapeutic efficacy in patients with isolated rotator cuff injury and those with rotator cuff injury and concurrent frozen shoulder. This study aims to provide additional insight for the treatment of different groups of patients with rotator cuff injury in clinical practice.

Materials and methods

Clinical data

A retrospective analysis was conducted on 85 patients who underwent arthroscopic shoulder surgery at Hanzhong Central Hospital between October 2016 and October 2021. Within this cohort, 42 patients with rotator cuff injuries only were designated as Group A, whereas 43 patients with concurrent frozen shoulder and rotator cuff injuries were assigned to Group B.

Inclusion criteria: (1) Patients in Group A were included based on diagnostic confirmation of rotator cuff injury [9]. Patients in Group B were included based on diagnostic confirmation of frozen shoulder combined with rotator cuff injury [10]. (2) Patients with complete clinical data. Exclusion Criteria: (1) Patients with incomplete clinical data. (2) Patients with comorbid psychiatric disorders or cognitive impairment. (3) Patients with severe pathologies in vital organs, such as the heart, rendering them unable to withstand surgical intervention. This study was approved by the ethics committee of Hanzhong Central Hospital (No. 2023-36) and complied with the Helsinki Declaration.

Surgical procedures: (1) To ensure the scientific validity of the study to the greatest extent, surgeries for both groups of patients in this study were performed by the same team of seasoned physicians. Before surgery, a thorough examination of the shoulder joint status of all patients was conducted, observing the preoperative shoulder joint activity and restrictions, with meticulous data documentation. (2) General anesthesia with controlled hypotension was applied to both groups of patients. Propofol (Sichuan Guorui Pharmaceutical, H20040079, 10 mL:0.1 g) was administered via intravenous injection at a dose of 1.5 mg/kg, along with Midazolam (Jiangsu Renfu Pharmaceutical, H20071096) at a dose of 0.05 mg/kg, and Sufentanil (Yichang Enhua Pharmaceutical, H20065310) at a dose of 0.2 μg/kg.

Following muscle relaxation, patients were connected to an anesthesia workstation for positive pressure intermittent ventilation, with the I:E ratio set at 1:2, respiratory rate set at 11 breaths/min, and tidal volume set in the range of 7 to 9 mL/kg. Then, both groups underwent controlled hypotension with a loading dose of 1 μg/kg dexmedetomidine infused within 10 minutes, followed by a maintenance dose at a concentration of 0.2-0.6 μg/kg/h (4 mg/ml). In both groups, mean arterial pressure (MAP) was controlled to be ≥70% of the baseline value, with MAP maintained at ≥60 mmHg.

Following the induction of general anesthesia in the lateral decubitus posture, the shoulder stability and mobility of patients were assessed. The surgical procedure started with a posterior approach, creating an approximately 1 cm incision below the outer edge of the acromion, with a total incision length of approximately 2 cm. Blunt trocars and cannulas were introduced into the joint cavity, aided by arthroscopy. An anterior portal was established by making an incision approximately 10 mm lateral to the edge of the coracoid process, and a pre-prepared cannula was inserted into the joint cavity. Arthroscopy was employed to visualize the detailed structure of the glenohumeral joint, and hypertrophic synovial tissue within the joint cavity was meticulously excised.

Table 1. Comparison of general data between two groups of patients

Variable	Group A n=42	Group B n=43	χ^2	P
Gender			0.013	0.911
Male	22 (52.38)	22 (51.16)		
Female	20 (47.62)	21 (48.84)		
Age (years)			0.120	0.729
≥62	25 (59.52)	24 (48.98)		
<62	17 (47.22)	19 (52.78)		
BMI (kg/m^2)			0.104	0.748
≥23	21 (50.00)	20 (46.51)		
<23	21 (50.00)	23 (53.49)		
Smoking history			0.159	0.690
Yes	30 (71.43)	29 (67.44)		
No	12 (28.57)	14 (32.56)		
Alcohol consumption history			0.171	0.679
Yes	31 (73.81)	30 (69.77)		
No	11 (26.19)	13 (30.23)		
Thyroid disease			0.107	0.744
Yes	22 (52.38)	21 (48.84)		
No	20 (47.62)	22 (51.16)		
Diabetes			0.579	0.447
Yes	23 (54.76)	20 (46.51)		
No	19 (45.24)	23 (53.49)		

In cases of L-shaped tears, the tear site was identified and sutured for fixation. For more severe U-shaped tears, edge suturing was initially performed, followed by additional fixation. All fixation procedures utilized rivets.

Observation parameters: (1) Treatment efficacy was evaluated at 2 months after treatment for both groups: Markedly Effective: Restoration of normal shoulder joint activity and disappearance of shoulder pain. Effective: Improvement in shoulder joint activity function and alleviation of shoulder pain. Ineffective: No significant improvement in shoulder joint activity function and shoulder pain, or worsening. (2) The operative time and blood loss were compared between the two groups of patients. (3) Shoulder joint pain was assessed using VAS scores [11]: The shoulder joint pain status was assessed before treatment and at 2 weeks and 2 months after treatment for both groups. (4) Comparison of Constant-Murley shoulder joint function scores [12]: The shoulder joint functional status of both groups was assessed before treatment and at 2 weeks and 2 months after treatment. (5) The shoulder joint range of motion (ROM, forward flexion, abduction, and external rotation) were assessed for both groups: The ROM of shoulder joint was assessed before treatment and at 2 weeks and 2 months after treatment. (6) The incidence of complication was compared for both groups: Complications include joint capsule hemorrhage, shoulder joint instability, and muscle weakness. (7) Quality of Life at 2 months after treatment was assessed using the SF-36 scale [13]: Higher scores in each assessment indicate better quality of life. (8) The patients were stratified into good and poor prognosis groups based on their clinical outcome, and the factors influencing prognosis were analyzed.

Statistical methods

The collected data were processed, analyzed and visualized using SPSS 20.0 software and GraphPad Prism 8 software. The measured data were expressed as mean ± SD, and Student t-test and Paired t-test were used for inter-group comparison and intra-group comparison, respectively, expressed as t. The data at different time points were compared using a one-way repeated measures analysis of variance (ANOVA). Counted data were expressed as n (%) and compared using Chi-square test. Significant differences were indicated when $P<0.05$.

Results

Comparison of general data between the two groups

There were no evident differences identified in gender, age, BMI, etc. between the two groups, indicating that the two groups were comparable (all $P>0.05$, **Table 1**).

Comparison of treatment efficacy between the two groups

The overall treatment effectiveness in the observation group was 97.62%, which was significantly higher than 76.74% in the control group ($P=0.004$, **Table 2**).

Table 2. Comparison of treatment efficacy between two groups of patients [n (%)]

Curative effect	Group A n=42	Group B n=43	χ^2	P
Excellent	30 (71.43)	25 (58.14)	-	-
Effective	11 (26.19)	8 (18.64)	-	-
Ineffective	1 (2.38)	10 (23.26)	-	-
Overall response rate	41 (97.62)	33 (76.74)	8.218	0.004

Table 3. Comparison of surgical duration and blood loss between two groups of patients

Item	Group A n=42	Group B n=43	t	P
Surgical duration (min)	62.34±1.23	77.33±2.13		<0.001
Intraoperative blood loss (ml)	26.47±1.20	27.13±1.22		>0.05

Comparison of surgical duration and blood loss between two groups of patients

The surgical duration in Group B was significantly longer than that of Group A (P<0.05). However, there was no significant difference in intraoperative blood loss between the two groups (P>0.05), as shown in **Table 3**.

Comparison of VAS scores and Constant-Murley shoulder joint function scores between two groups of patients

Before treatment, the VAS score and the Constant-Murley shoulder joint function scores were comparable between the two groups. At 2 weeks after treatment, both groups showed significant improvement in VAS score and Constant-Murley score compared to baseline, with slightly higher VAS scores and lower Constant-Murley scores in Group B compared to Group A (all P>0.05). However, at 2 months after treatment, Group A patients demonstrated more significant improvement in VAS scores and Constant-Murley shoulder joint function score compared to Group B (both P<0.05) (**Figure 1**).

Comparison of shoulder joint ROM before and after the treatment between the two groups of patients

Before treatment, there were no significant differences in shoulder joint ROM between the two groups in terms of passive forward bend, passive outreach, orexternal rotation. At 2 weeks after treatment, both groups showed increased shoulder joint ROM compared to before treatment, although the inter-group differences were not significant (all P>0.05). After 2 months of treatment, group A exhibited significantly greater improvement in shoulder joint ROM (passive forward bend, passive outreach and external rotation) compared to group B (all P<0.05) (**Figure 2**).

Comparison of the incidence of postoperative adverse reaction between the two groups of patients

The incidence of adverse reactions in group A was 4.76%, and that of group B was 9.30%. There was no significant difference in the incidence of postoperative complications between the two groups (P=0.414) (**Table 4**).

Comparison of quality of life between the two groups of patients after treatment

After treatment, patients in group A exhibited significantly higher quality of life scores across various domains than those in group B, indicating a superior quality of life among Group A individuals (all P<0.001, **Table 5**).

Analysis of risk factors affecting patient prognosis

Patients were divided into a good prognosis group (n=60) and a poor prognosis group (n=25) based on whether adverse outcomes occurred (including re-operation, arthritis, and nerve damage). Initial single-factor analysis revealed that age, diabetes, thyroid disease, and the presence of frozen shoulder were factors influencing prognosis (**Table 6**). Subsequently, logistic regression analysis confirmed that age, diabetes, thyroid disease, and the presence of frozen shoulder were independent risk factors for poor prognosis (all P<0.05, **Table 7**).

Discussion

Rotator cuff injuries are common causes of shoulder pain and functional impairment, particularly among individuals engaged in repetitive shoulder movements, including laborers

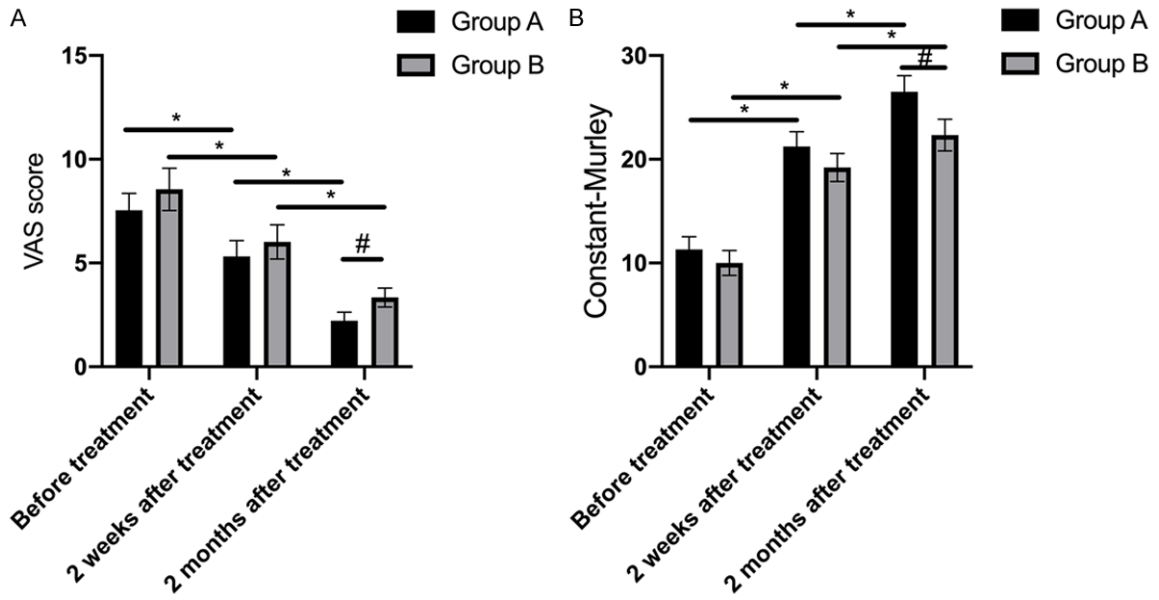

Figure 1. Comparison of VAS score and Constant-Murley shoulder joint function score between the two groups of patients. A. Comparison of VAS score between the two groups. B. Comparison of Constant-Murley shoulder joint function score between the two groups. *, P<0.05 compared to different time points within the group; #, P<0.05 compared between the two groups 2 months after treatment.

and athletes. Epidemiologic evidence reveals an increased prevalence of this condition in individuals aged 60 and above, steadily rising with advanced age [14]. Frozen shoulder, or primary adhesive capsulitis, mainly affects the deep layers of the joint capsule enveloping the glenohumeral joint, leading to significant pain and restricted shoulder joint mobility, especially in external rotation, impacting both active and passive shoulder movement [15].

Research indicates that rotator cuff injuries constitute approximately 45% to 55% of all shoulder injuries. However, in comparison to shoulder fractures or dislocations, they have not received adequate attention in clinical diagnosis and treatment [16]. Muscle and tendon tissue contracture, inflammation of the shoulder joint capsule, and underlying conditions such as diabetes, thyroid disorders, and autoimmune diseases may all contribute to the development of frozen shoulder following rotator cuff injury [17, 18]. Frozen shoulder not only severely impacts a patient's quality of life but also imposes a substantial economic burden on families and society. Currently, the pathogenesis of frozen shoulder remains unclear, with capsular adhesion or fibrosis being the primary pathologic changes. Both domestically and internationally, definitive treatment protocols for this condition are yet to be established [19]. The primary goal for the treatment is to alleviate pain, assist patients in regaining functional mobility, and reduce the duration of illness.

Currently, arthroscopic repair stands as the primary treatment modality for rotator cuff injury. This surgical approach fully utilizes the benefits of arthroscopy, enabling a meticulous assessment of the patient's shoulder joint, precise evaluation of pathologic changes in the glenohumeral joint, and more accurate management of shoulder joint injuries [20]. However, the definitive superiority of arthroscopy in patients with concurrent frozen shoulder requires further validation. At present, the treatment for this condition primarily focuses on pain alleviation, aiding patients in regaining enhanced mobility, and reducing the duration of illness [21].

In our investigation, we observed a notable disparity in the effectiveness of arthroscopic surgery between patients with isolated rotator cuff injury and those with rotator cuff injury combined with frozen shoulder. Subsequently, we compared VAS scores and Constant-Murley shoulder joint function scores between the two cohorts and found that patients with concur-

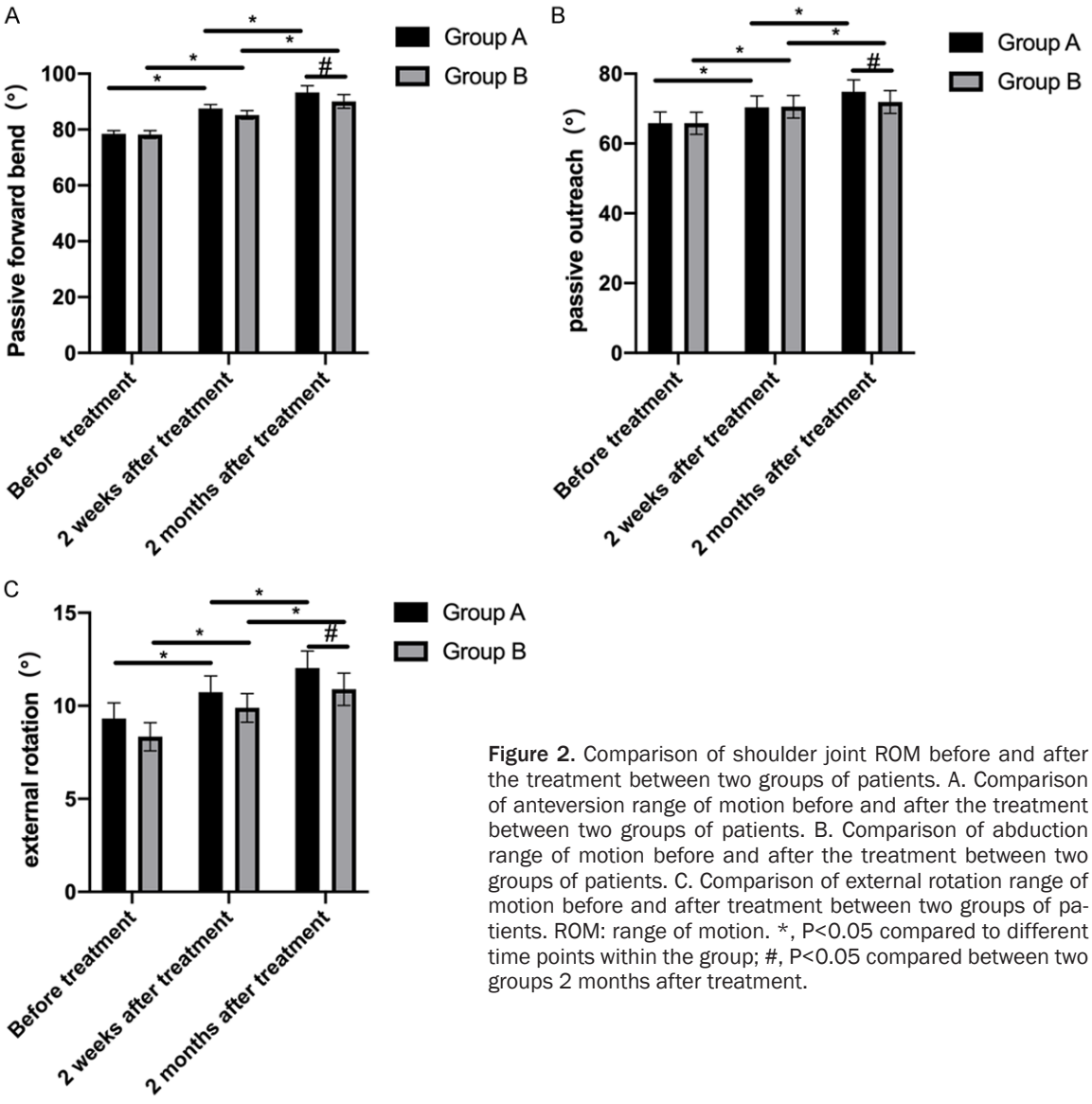

Figure 2. Comparison of shoulder joint ROM before and after the treatment between two groups of patients. A. Comparison of anteversion range of motion before and after the treatment between two groups of patients. B. Comparison of abduction range of motion before and after the treatment between two groups of patients. C. Comparison of external rotation range of motion before and after treatment between two groups of patients. ROM: range of motion. *, P<0.05 compared to different time points within the group; #, P<0.05 compared between two groups 2 months after treatment.

Table 4. Comparison of adverse reactions between two groups of patients

Complication	Group A n=42	Group B n=43	χ^2	P
Joint capsule bleeding	1 (2.38)	2 (4.65)	-	-
Shoulder joint instability	1 (2.38)	1 (2.32)	-	-
Weakened muscle strength	0	1 (2.32)	-	-
Total incidence	2 (4.76)	4 (9.30)	0.668	0.414

rent frozen shoulder exhibited elevated VAS scores both prior to and at 2 weeks after treatment, in contrast to patients with isolated rotator cuff injury. Regarding shoulder joint mobility, while both groups demonstrated increased shoulder joint mobility post-treatment, individuals with concurrent frozen shoulder exhibited inferior improvement in external rotation angle at the 2-week follow-up. Following a 2-month treatment period, patients in Group A exhibited significantly greater enhancement in VAS score, Constant-Murley shoulder joint function score, and shoulder joint mobility compared to their counterparts in Group B. This discrepancy can be ascribed to the restrictive nature of frozen shoulder, limiting both active and passive joint mobility, nota-

Table 5. Comparison of quality of life between two groups of patients after treatment

Item	Group A n=42	Group B n=43	t	P
Social functioning	77.41±1.59	67.77±2.19	23.18	<0.001
Mental status	76.31±2.22	68.29±1.92	17.83	<0.001
Health Status	87.89±2.26	80.88±2.34	14.04	<0.001
Emotional function	85.07±2.23	76.8±2.02	17.93	<0.001

Table 6. Univariate analysis

Variable	Good prognosis group (n=60)	Poor prognosis group (n=25)	t/χ^2	P
Gender			0.201	0.654
Male (n=44)	32 (53.33)	12 (48.00)		
Female (n=41)	28 (46.67)	13 (52.00)		
Age			7.248	0.007
≥62 (n=49)	29 (48.33)	20 (80.00)		
<62 (n=36)	31 (51.67)	5 (20.00)		
BMI			0.201	0.654
≥23 kg/m^2 (n=41)	28 (46.67)	13 (52.00)		
<23 kg/m^2 (n=44)	32 (53.33)	12 (48.00)		
Thyroid disease			24.30	<0.001
Yes (n=43)	20 (33.33)	23 (92.00)		
No (n=42)	40 (66.67)	2 (8.00)		
Diabetes			19.83	<0.001
Yes (n=43)	21 (35.00)	22 (88.00)		
No (n=42)	39 (65.00)	3 (12.00)		
Rotator cuff injuries			15.82	<0.001
Single rotator cuff injury (n=42)	38 (63.33)	4 (16.00)		
Rotator cuff injury combined with frozen shoulder (n=43)	22 (36.67)	21 (84.00)		

Table 7. Multivariate analysis

Variable	B	S.E.	Wals	P	RR	95% C.I.	
						Lower limit	Upper limit
Diabetes	2.753	0.711	11.785	0.002	12.303	3.102	50.204
Rotator cuff injuries	1.605	0.648	5.582	0.024	4.983	1.375	18.021
Age	3.273	0.805	15.575	0.001	28.133	5.166	152.356
Thyroid disease	2.605	0.702	10.019	0.001	9.711	3.233	55.692

bly in external rotation, followed by abduction, flexion, and internal rotation. In contrast, rotator cuff injury predominantly impedes active mobility, while passive mobility is generally preserved [22]. Consequently, patients with rotator cuff injury combined with frozen shoulder may need a longer recovery period. Additionally, our results revealed a significantly longer operation time for patients in Group B compared to those in Group A. This discrepancy may be attributed to the greater complexity of the injury scenario in patients from Group B.

Subsequently, we compared the incidence of complications between the two patient groups and found that both groups exhibited low complication rates, with no significant difference observed between groups. This implies that arthroscopic shoulder surgery is a safe procedure for patients with either isolated rotator cuff injury or rotator cuff injury combined with frozen shoulder.

We further analyzed the risk factors influencing the effectiveness of arthroscopic shoulder sur-

gery, and demonstrated that age, the type of rotator cuff injury, and diabetes all emerged as independent risk factors influencing the outcome. Regarding age, older individuals tend to experience a decline in physical fitness and often exhibit degenerative changes in multiple body parts, leading to a reduced rate of physiologic recovery [23]. In terms of the type of rotator cuff injury, patients with combined frozen shoulder typically experience more severe pain, and their shoulder adhesions are more pronounced, limiting treatment efficacy [24]. Previous studies have suggested that muscle and tendon contracture, inflammation of the shoulder joint synovial sac, as well as underlying conditions such as diabetes, thyroid disorders, and autoimmune diseases, may all contribute to the development of frozen shoulder as a complication following rotator cuff injury [25], aligning with our analytical findings.

In summary, arthroscopic shoulder surgery has demonstrated favorable efficacy and safety in the treatment of frozen shoulder combined with rotator cuff injury, as well as isolated rotator cuff injury. However, its effectiveness appears to be more pronounced in patients with simple rotator cuff injury. Nevertheless, this study has certain limitations. First, the relatively small sample size may necessitate further confirmation of the observations. Additionally, our study exclusively employed arthroscopic shoulder surgery as the treatment modality, leaving room for further analysis to explore the suitability of alternative surgical approaches to frozen shoulder combined with rotator cuff injury and for those with isolated rotator cuff injury.

Disclosure of conflict of interest

None.

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References

[1] Zhang M, Zhou J, Zhang Y, Zhang X, Chen J and Chen W. Influence of scapula training exercises on shoulder joint function after surgery for rotator cuff injury. Med Sci Monit 2020; 26: e925758.

[2] Oh JH, Park MS and Rhee SM. Treatment strategy for irreparable rotator cuff tears. Clin Orthop Surg 2018; 10: 119-134.

[3] Fitzpatrick LA, Atinga A, White L, Henry PDG and Probyn L. Rotator cuff injury and repair. Semin Musculoskelet Radiol 2022; 26: 585-596.

[4] Keener JD, Patterson BM, Orvets N and Chamberlain AM. Degenerative rotator cuff tears: refining surgical indications based on natural history data. J Am Acad Orthop Surg 2019; 27: 156-165.

[5] Ueda Y, Sugaya H, Takahashi N, Matsuki K, Kawai N, Tokai M, Onishi K and Hoshika S. Rotator cuff lesions in patients with stiff shoulders: a prospective analysis of 379 shoulders. J Bone Joint Surg Am 2015; 97: 1233-1237.

[6] He L, Li Y, Liao X, Wang Y, Pu L, Gao F and Wang G. Effects of evidence-based nursing combined with enhanced recovery after surgery on shoulder joint function and neurological function after arthroscopic rotator cuff injury repair. Medicine (Baltimore) 2021; 100: e27951.

[7] Wang H, Hu F, Lyu X, Jia H, Wang B, Liu F and Yang Y. Kinesiophobia could affect shoulder function after repair of rotator cuff tears. BMC Musculoskelet Disord 2022; 23: 714.

[8] Li S, Sun H, Luo X, Wang K, Wu G, Zhou J, Wang P and Sun X. The clinical effect of rehabilitation following arthroscopic rotator cuff repair: a meta-analysis of early versus delayed passive motion. Medicine (Baltimore) 2018; 97: e9625.

[9] Weber S and Chahal J. Management of rotator cuff injuries. J Am Acad Orthop Surg 2020; 28: e193-e201.

[10] Millar NL, Meakins A, Struyf F, Willmore E, Campbell AL, Kirwan PD, Akbar M, Moore L, Ronquillo JC, Murrell GAC and Rodeo SA. Frozen shoulder. Nat Rev Dis Primers 2022; 8: 59.

[11] Ebadi S, Forogh B, Fallah E and Babaei Ghazani A. Does ultrasound therapy add to the effects of exercise and mobilization in frozen shoulder? A pilot randomized double-blind clinical trial. J Bodyw Mov Ther 2017; 21: 781-787.

[12] Vrotsou K, Avila M, Machon M, Mateo-Abad M, Pardo Y, Garin O, Zaror C, Gonzalez N, Escobar A and Cuellar R. Constant-Murley Score: systematic review and standardized evaluation in different shoulder pathologies. Qual Life Res 2018; 27: 2217-2226.

[13] Lins L and Carvalho FM. SF-36 total score as a single measure of health-related quality of life: scoping review. SAGE Open Med 2016; 4: 2050312116671725.

[14] Aim F, Chevallier R, Marion B, Klouche S, Bastard C and Bauer T. Psychological risk factors

for the occurrence of frozen shoulder after rotator cuff repair. Orthop Traumatol Surg Res 2022; 108: 103212.
[15] Ko JY, Lian WS, Tsai TC, Chen YS, Hsieh CK, Kuo CW and Wang FS. MicroRNA-29a mitigates subacromial bursa fibrosis in rotator cuff lesion with shoulder stiffness. Int J Mol Sci 2019; 20: 5742.
[16] Muench LN, Rupp MC, Obopilwe E, Mehl J, Scheiderer B, Siebenlist S, Elhassan BT, Mazzocca AD and Berthold DP. Physiological tensioning during lower trapezius transfer for irreparable posterosuperior rotator cuff tears may be important for improvement in shoulder kinematics. Am J Sports Med 2023; 51: 2422-2430.
[17] Cucchi D, Menon A, Maggi S, Feroldi FM, De Silvestri A, Friedrich MJ, Wimmer MD and Randelli PS. Treatment of partial rotator cuff lesions is associated with a higher frequency of post-operative shoulder stiffness. A prospective investigation on the role of surgery-related risk factors for this complication. Arch Orthop Trauma Surg 2022; 142: 3379-3387.
[18] Nishimoto H, Fukuta S, Fukui N, Sairyo K and Yamaguchi T. Characteristics of gene expression in frozen shoulder. BMC Musculoskelet Disord 2022; 23: 811.
[19] Challoumas D, Biddle M, McLean M and Millar NL. Comparison of treatments for frozen shoulder: a systematic review and meta-analysis. JAMA Netw Open 2020; 3: e2029581.
[20] Duzgun I, Turgut E, Eraslan L, Elbasan B, Oskay D and Atay OA. Which method for frozen shoulder mobilization: manual posterior capsule stretching or scapular mobilization? J Musculoskelet Neuronal Interact 2019; 19: 311-316.
[21] Maund E, Craig D, Suekarran S, Neilson A, Wright K, Brealey S, Dennis L, Goodchild L, Hanchard N, Rangan A, Richardson G, Robertson J and McDaid C. Management of frozen shoulder: a systematic review and cost-effectiveness analysis. Health Technol Assess 2012; 16: 1-264.
[22] Ryan V, Brown H, Minns Lowe CJ and Lewis JS. The pathophysiology associated with primary (idiopathic) frozen shoulder: a systematic review. BMC Musculoskelet Disord 2016; 17: 340.
[23] Cho CH, Lee YH, Kim DH, Lim YJ, Baek CS and Kim DH. Definition, diagnosis, treatment, and prognosis of frozen shoulder: a consensus survey of shoulder specialists. Clin Orthop Surg 2020; 12: 60-67.
[24] Wang L, Yu G, Zhang R, Wu G, He L and Chen Y. Positive effects of neuromuscular exercises on pain and active range of motion in idiopathic frozen shoulder: a randomized controlled trial. BMC Musculoskelet Disord 2023; 24: 50.
[25] Hammad SM, Arsh A, Iqbal M and Khan W; Bilal; Shah A. Comparing the effectiveness of kaltenborn mobilization with thermotherapy versus kaltenborn mobilization alone in patients with frozen shoulder [adhesive capsulitis]: a randomized control trial. J Pak Med Assoc 2019; 69: 1421-1424.