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Comparisons of shoulder function after treatment of floating shoulder injuries with different methods.

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Abstract

This study aims to investigate appropriate treatment methods for floating shoulder injury (FSI). Fifty-six FSI patients treated from February 2006 to August 2014 were enrolled, and divided into three groups: a nonsurgical treatment group (Group A), a surgical treatment with single clavicular fixation group (Group B), and a surgical treatment with combined clavicular and scapular fixation group (Group C). The Herscovici FS efficacy scoring system and the Constant-Murley shoulder scoring systems were used to score affected shoulder functions. The variables of these three groups were compared with the one-way ANOVA. The follow-up was 17.1 months (6 to 30 months), and all fractures healed. The scores of the three groups had statistically significant differences. Regardless of the Herscovici or Constant scores, group A showed significant differences when compared with groups B and C, but there was no difference between groups B and C; however, there were significant differences in operative time and intraoperative blood loss. Surgery showed an obvious advantage for the restoration of shoulder functions in FSI patients; although the single clavicular fixation and the combined clavicular and scapular fixation showed no difference, single clavicular fixation had lower treatment risks.

Keywords: Scapula, Clavicle, Fracture, Floating shoulder injuries, Shoulder function.

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Introduction

In 1993, Goss [1] first defined the bone-ligament cyclic structure composed of the coracoid, coracoclavicular ligament, distal end of the clavicle, acromioclavicular joint, acromion, and superior part of the glenoid cavity, as the superior shoulder suspensory complex (SSSC) that connected the upper limbs with the axial skeleton. When the SSSC was injured, the stability of shoulder suspension would sustain serious damage; the local muscle tension and weight of the affected limb would make the distal end of the fractured limb generate rotation and displacement forward, downward, and inward. This 3-dimensional displacement would change the start-end relationships and the structural length of the acromion and the muscles around the glenohumeral joint, resulting in a dynamic power imbalance of the shoulder joint. If not treated properly in the early injury period, this could lead to malunion, a drooping shoulder deformity, shoulder pain and weakness, subacromial impingement syndrome, traumatic arthritis, and even delayed nerve and vascular damage and other complications [2].

In 1975, Ganz and Noesberger [3] defined a scapular neck fracture associated with an ipsilateral clavicular shaft fracture as a floating shoulder injury (FSI), which was now considered a type of SSSC injury [4]. There was still no consensus about a gold standard of treatment. Edwards et al. [5] thought that this could be treated conservatively, especially in those with small displacements (less than 5 mm), to avoid the risk of surgical complications. Other authors [6,7] thought that when FSI occurred, regardless of the initial displacement, open reduction and internal fixation should be performed, to avoid limitation of shoulder function. Van Noort et al. [8] thought that FSI was not always stable, and that if the scapula did not exhibit downward rotation and displacement, conservative treatment could achieve good results. Anavian et al. [9] suggested that for complex fractures of the glenoid cavity accompanied by displacement, whether the scapular neck or body was involved or not, surgical treatment would have good effects. Egol et al. [10] reported that surgery could not be used for routine treatment, and that each patient must undergo individualized therapy.

In light of these conflicting reports, the author retrospectively studied and compared shoulder function using three treatment methods (nonsurgical, surgery with only clavicular fixation, and surgery with combined clavicular and scapular fixation), in order to determine optimal treatment for FSI.

Materials and Methods

General information

We selected 69 FSI patients treated in our hospital from February 2006 to August 2014. Of these, 13 were lost during follow-up, and the remaining 56 enrolled included 40 men and 16 women (age range, 18 to 66 years, mean age, 38.7 years). Results for each variable were adjusted for age, race, and the other risk factors listed. This study was conducted in accordance with the declaration of Helsinki, and was conducted with approval from the Ethics Committee our University. Written informed consent was obtained from each participant.

Typing: Clavicular fracture was classified according to the Craig method. There were 37 cases of middle third, 18 cases of distal third, and 1 case of proximal third clavicular fracture. Scapular fracture was classified according to the Miller method. There were 3 cases of type I (acromion, scapular spine, coracoid), 33 cases of type II (scapular neck), 17 cases of type III (glenoid cavity), and 3 cases of type IV (scapular body) fracture; 17 cases were on the left, and 39 were on the right. Causes of FSI included 33 due to a traffic accident, 16 due to falling, 4 due to a heavy blow, and 3 due to a crush injury.

Associated injuries included: 16 cases of rib fracture, hemopneumothorax, and pulmonary contusion; 10 cases of spinal fracture; 9 of limb fracture; 1 of pelvic and acetabular fracture; 11 of traumatic brain injury; 1 of blunt abdominal trauma; and 2 of brachial plexus injury. All fractures were closed.

Treatment

All patients underwent routine normal and lateral radiographs of the shoulder. To better understand fracture morphology, some patients underwent computed tomography (CT) with 3-dimensional reconstruction; if a patient was suspected to have associated injuries of the ligaments, rotator cuff, glenoid lip, or joint capsule, magnetic resonance imaging (MRI) was performed. The glenopolar angle (GPA) was measured from the normal X-ray film [11].

In group A, 6 cases had smaller displacement, and 4 had been treated for combined injuries of other areas for>2 months; as a result, the fractures of these 10 cases had healed; the other 2 cases declined surgery. Group A was treated with a bandage or plaster-assisted neck and wrist sling, triangular scarf suspension, or outreaching-frame fixation, and received symptomatic analgesia; 4 to 6 weeks later, the patients in group A started shoulder range of motion (ROM) exercises. Radiographs were reviewed 6 to 8 weeks later; when fracture healing was confirmed, external fixation was removed, and ROM exercises and strength training were advanced. The 44 patients in group B and C underwent general comprehensive assessment, and life-threatening injuries were first dealt with. After stabilization, open reduction and internal fixation were performed. Group B (12 patients) only underwent clavicular fixation, while group C (15 patients) underwent combined clavicular-scapular fixation; the internal fixation material was a straight or curved reconstruction plate (Smith & Nephew, Inc., Memphis, TN, USA).

Surgical indications: Displacement of a clavicular fracture by ≥ 5 mm; accompanying displacement of a scapular neck fracture ≥ 10 mm, or angular deformity ≥ 40; obvious scapular body fracture displacement or a fracture of the exterior edge of the body with penetration into the glenohumeral joint, affecting the shoulder joint; scapular neck fracture combined with glenoid cavity fracture, and articular surface exhibiting clear separation or step-like displacement ≥ 3 mm; coracoid fracture accompanied by coracoacromial or coracoclavicular ligament injury, with separation and displacement, or compression of blood vessels and nerves, requiring early surgical exploration; shoulder fracture subsidence>5 mm, affecting the function of the rotator cuff and the motion of the inferior acromial joint; spine scapular fracture>5 mm or comminuted fracture, affecting the normal sliding of anterior and inferior spine scapular muscles; GPA<20°; other combined structural damage of the SSSC with significant displacement, and with conservative treatment expected to result in a poor outcome.

Time from injury to surgery: ≤ 7 days in 11 cases, 7 to 21 days in 26 cases, > 21 days in 7 cases (Table 1). Surgical methods: 44 surgeries were performed by the same group of doctors. First, the clavicular fracture was exposed and fixed; if further internal fixation of the scapular fracture was needed, the modified Judet posterior approach or a straight incision over the exterior scapula was performed to treat the scapular neck fracture.

Table 1. Perioperative data.

	Group A	Group B	Group C	P value		
	(12 cases)	(29 cases)	(15 cases)	Group A and B	Group A and C	Group B and C
M: F	7:5	18:11	11:4			
Age (years, $\bar{x} \pm s$)	45.08 ± 13.47	37.28 ± 10.43	36.20 ± 9.50	0.681	0.407	0.149
Causes of FSI						
Traffic Injury	7	17	9			

Falling injury	3	9	4			
Heavy strike injury	1	2	1			
Crush injury	1	1	1			
Typing						
Clavicular fracture (Craig)						
First type (middle 1/3)	7	20	10			
Second type (distal 1/3)	4	9	5			
Third type (proximal 1/3)	1	0	0			
Scapular fracture (Miller)						
I	1	3	1			
II	6	15	10			
III	4	10	2			
IV	1	1	2			
Accompanied injuires						
Rib fracture, hemopneumothorax, pulmonary contusion	4	8	4			
Spinal fracture	2	6	2			
Limb fracture	3	4	2			
Pelvic fracture	0	1	0			
Traumatic Brain Injury	1	7	3			
Blunt abdominal trauma	0	1	0			
brachial plexus N injury	0	1	1			
Imaging						
glenopolar angle (°)	18.75 ± 3.60	18.97 ± 4.72	17.80 ± 4.41	0.888	0.582	0.412
Healing time (weeks)	12.67 ± 2.87	13.03 ± 2.37	13.33 ± 2.79	0.681	0.51	0.719
Complication						
Malreduction	7	2	0			
Wound infection	/	1	0			
Delayed healing	1	1	0			
"Droopy" Shoulder	3	2	0			
Follow-up time (months)	16.75 ± 6.00	17.38 ± 4.61	17.00 ± 4.47	0.71	0.896	0.809

Postoperative treatment

Patients underwent triangular scarf suspension for the fixation, and the exercise time was determined by the fixation stability of the fracture. Patients with a stable fracture started passive anterior-posterior swing movement two days after surgery, and progressed to active exercises 1 to 2 weeks later. Patients with unstable fractures started passive exercises 2 to 3 weeks later and active functional exercises 4 to 6 weeks later. In patients with a modified Judet incision, shoulder movement within the first month could not extend past the midline, because the deltoid muscle or inferior spine scapular muscle were cut off; active functional exercises could be started a month later, and weight-bearing activities could be performed three months later.

Follow-up and scoring criteria

Patients were followed up once per month for the first 3 months after surgery, then once every 3 months. Follow-up included normal and lateral radiographs of the shoulder, ROM and muscle strength assessment, and shoulder function scoring at final follow-up. Scoring used the Herscovici FSI efficacy scoring system [12] and the Constant-Murley shoulder scoring system [13].

Statistical analysis

Data were expressed as $\bar{x} \pm s$, and SPSS 19.0 software was used to perform the independent sample t-test for the intraoperative data; the comparison of preoperative data and postoperative shoulder function among the three groups were analysed. Where appropriate, statistical significance was assessed by unpaired Students T tests or one-way ANOVA, with P<0.05 considered as the statistical significance to perform the statistical analysis towards the data.

Results

General conditions

The average follow-up time for the 56 patients was 17.1 months (6-30 months), and the preoperative GPA was 18.6° (11°~30°) (Table 2).

Table 2. *Comparison of intraoperative data between the 2 groups.*

	Group B (29 cases)	Group C (15 cases)	P
Time interval from injury to operation (days)			
≤ 7 day	8	3	
7-21 days	17	9	
>21 days	4	3	
Operation time (min)	36.21 ± 8.63	122.80 ± 20.43	0.000
Intraoperative blood loss (ml)	62.41 ± 28.37	386.67 ± 151.74	0.000

All fractures healed, and the average healing time was 13.0 months (8-20 months); the pairwise comparison among the 3 groups showed no statistical difference (P>0.05).

Intraoperative conditions

The average operative time of group B was 36.2 min (20~55 min); the average intraoperative blood loss was 62.4 ml (10~90 ml). The average operative time of group C was 122.8 min (90~160 min); the average intraoperative blood loss was 386.7 ml (150~800 ml) (Table 1). The comparison of these 2 groups showed statistical significance (P<0.05).

Scores of shoulder functions

The Herscovici FSI efficacy scores were: group A, 9.33 ± 2.27 (6~13); group B, 12.90 ± 1.76 (8~15); and group C, 13.00 ± 1.85 (9~16). The Constant-Murley shoulder scores were: nonsurgical group A, 74.00 ± 11.22 (48~90); group B, 84.86 ± 6.84 (70~98); and group C, 85.67 ± 7.21 (70~98). The above results showed that regardless of the Herscovici or the Constant scores, group A showed significant differences with groups B and C (P<0.05), but no statistical difference was detected between group B and group C (P>0.05) (Table 3).

Table 3. *Scoring of shoulder functions.*

	Group A (12 cases)	Group B (29 cases)	Group C (15 cases)	P		
				Group A and B	Group A and C	Group B and C
Herscovici FSI efficacy scoring system	9.33 ± 2.27	12.90 ± 1.76	13.00 ± 1.85	0	0	0.865
Constant-Murley shoulder scoring system	74.00 ± 11.22	84.86 ± 6.84	85.67 ± 7.21	0	0	0.754

Age

The age difference in this study was large, at 18 to 66 years (mean: 38.66 ± 11.24 years); however, the P values between groups A and B, A and C, and B and C, were 0.681, 0.407, and 0.149, respectively, indicating that there was no statistical difference in age (Table 2).

Complications

Among the 56 patients, 51 exhibited symmetric and normal shoulder appearance postoperatively, and 5 exhibited a droopy shoulder. There were 9 cases of poor fracture healing (7 in group A, and 2 in group B). Two patients had combined incomplete brachial plexus injuries; sensation and motion in 1 case fully recovered within 3 months, with full recovery in the other case within 5 months. Two cases of delayed healing (clavicle) achieved recovery through active intervention (external fixation plus physical therapy, etc.). One case of wound infection achieved delayed healing after active interventions for the wound (dressings, etc.).

Discussion

Because the scapula is deep to the surface and is heavily covered by muscles, it is protected when subjected to violent injury; thus, the incidence of scapular fractures is small, accounting for 3% to 5% of shoulder fractures, and 0.4% to 1% of all body fractures [14]. Therefore, the incidence of clavicular fractures accompanied by an ipsilateral scapular neck fracture, i.e., FSI, is small; however, if this type of injury occurs, it is often associated with high-energy trauma. Injuries combined with damage to other areas account for 97.8% [8]; in this study, the rate was 89.29% (50/56) (Table 2). Most concomitant injuries were serious and needed to be treated first, which complicated the treatment of the FSI. Four patients had delayed treatment of FSI due to the need to treat concomitant injuries, and therefore underwent passive conservative treatment.

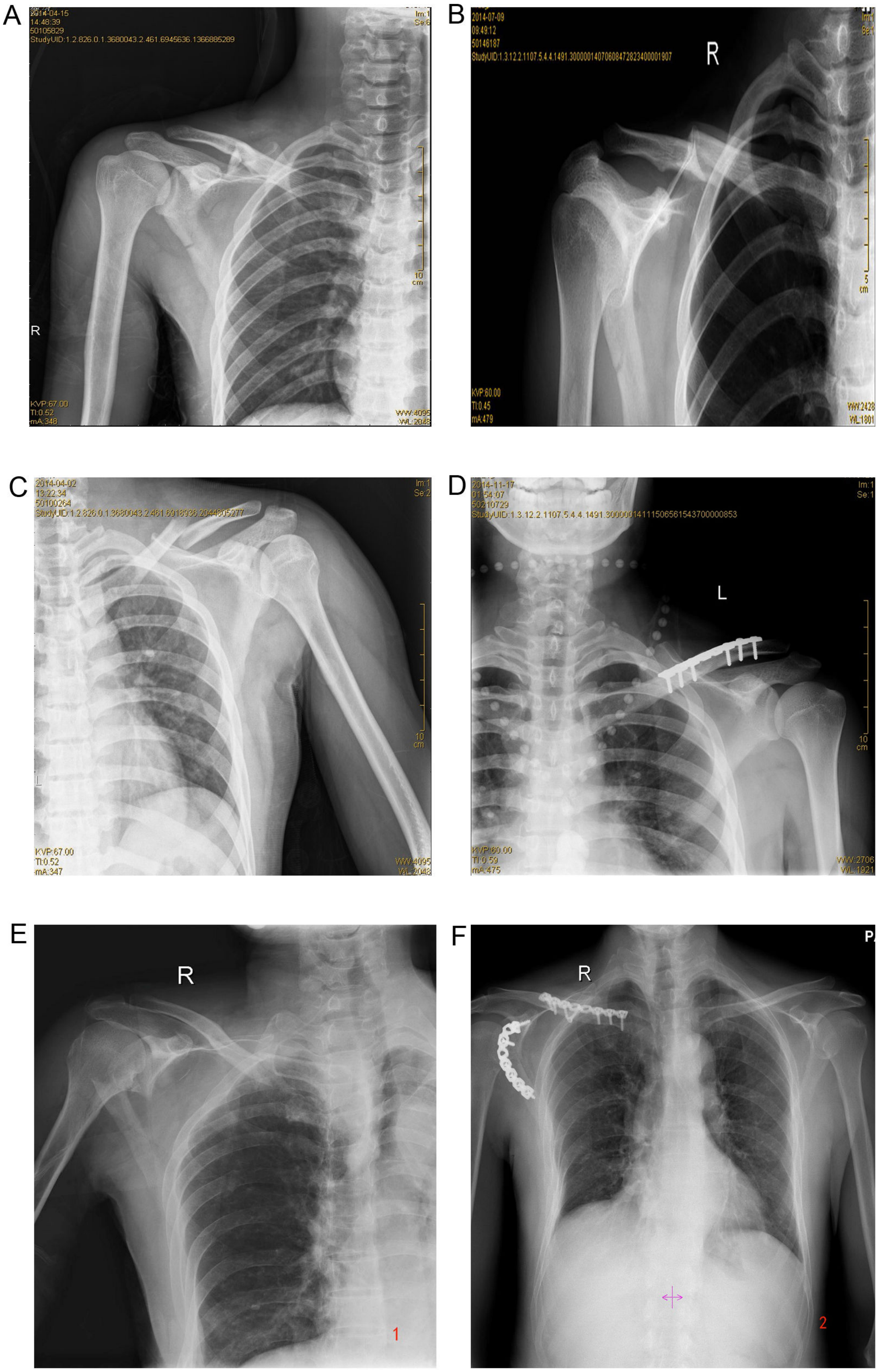

Figure 1. The imagines for three groups before and after treatments; A: nonsurgical treatment group; B: a surgical treatment with single clavicular fixation group; C: a surgical treatment with combined clavicular and scapular fixation group.

FSI is a complex injury, and damage to shoulder function is much greater than that due to fracture of a single part. There is still no consensus on treatment, and the selection of nonsurgical or surgical management is based more on the physician's personal experience. There is also no large-sample, long-term clinical follow-up study with which to compare shoulder function after different treatments. Most authors focused on evaluating the outcomes of a single method or compared the outcomes for conservative and surgical methods. Ramos et al. [15] performed nonsurgical treatment on 13 patients, and 12 achieved good results. Van Noort et al. [8] reported that FSI was not always unstable; if the scapula did not exhibit downward rotation and displacement, conservative treatment could also achieve good results. Herscovici et al. [12] reported that the internal fixation of a scapular neck fracture accompanied by an ipsilateral clavicular fracture achieved good clinical results. In this study, we retrospectively analyzed shoulder function after treatment with three methods; the Herscovici and Constant-Murley scores of the nonsurgical treatment group exhibited significant differences from the two surgical treatment groups ($P<0.05$). If the patient can tolerate surgery, this should be the initial treatment. In this manner, the continuity of the SSSC can be restored, the rotation of the glenoid can be prevented, and the length and tension of the muscles around the shoulder joint and the power balance and stability of the shoulder joint can be restored. Simultaneously, good reduction and fixation can restore the normal leverage roles of the rotator cuff in the upper extremity, thus providing an anatomic and power base for the early exercise of the shoulder joint (Figure 1). Patients selected for conservative treatment might exhibit muscle disuse atrophy and shoulder joint adhesions if accompanied by fracture displacement, because of early exercise with an unhealed fracture. Obviously, this conclusion had been reached by most authors [1,12,16], and such complex injuries required surgery to restore shoulder function.

Goss [1] thought that if one fracture inside the complex structure of the SSSC still maintained structural integrity, two ruptures might lead to an unstable relationship between the shoulder girdle and axial skeleton. Could the existence of two ruptures in SSSC be called FSI? Williams et al. [17] found that a simple pillar injury without ligament rupture would not produce instability of the shoulder, and pointed out that the stability of a fracture accompanied by ligament injuries would result in severe damage. FSI was either a "true" or a "pseudo" injury. Therefore, the diagnosis and treatment of FSI should not only consider the clavicular and scapular neck fracture, but the impact of soft tissue structural damage involving the coracoacromial, coracoclavicular, and acromioclavicular ligaments, among others, on the stability of the fracture. Recent reports [18-21] indicated that three or more injuries inside the SSSC structure, although rare, might have serious effects on shoulder function, making restoration of the SSSC structure essential.

There remained controversy about whether to repair one or two fractures in FSI [1,2,12,16]. Toro and Helfet [22] thought that simple clavicular fracture fixation could be considered; otherwise, the scapular neck fracture should be fixed at the same time. Van Noort et al. [8] reported that the postoperative obliquity and displacement of the glenoid cavity was not significantly improved. Ramsey et al. [23] proposed that the glenoid displacement degree might be the most important factor affecting shoulder function, and that normal anatomic structure and function of the shoulder joint should be restored through surgery. Rikli et al. [6] believed that unstable shoulder girdle fractures should undergo surgery for internal fixation as soon as possible, so that early functional exercise could be performed. In the present study, no difference in shoulder function was detected between groups B and C after the fracture healed ($P>0.05$), but significant differences in operative time and intraoperative blood loss were detected ($P<0.05$). Surgery for FSI should first repair the clavicle; thus, one broken component of the SSSC could be stabilized, partial SSSC structure might be restored, and the scapular fracture could often reset itself. If partial improvement of displacement could be obtained, the intraoperative displacement status of the scapular neck fracture and ligament stability could be used to determine whether to perform further fixation of the scapular fracture under the following conditions: an unstable FSI accompanied by coracoacromial and coracoclavicular ligament rupture; inward displacement of a scapular neck fracture >10 mm, or anterior/posterior angulation >40°; GPA<20°; or need for further fixation of a scapular fracture.

Why the tendency to choose single plate fixation for the clavicle? Matsumura et al. [24] reported that clavicular discontinuity would affect the movement of the shoulder joint, and that clavicular function could assist glenohumeral motion and prevent the occurrence of subacromial impingement; the first step in restoring the power balance and maintaining the stability of the shoulder joint was to restore the integrity and stability of the clavicle. Because of loss of clavicular bone support and suspension, the scapular neck fracture generates displacement and instability; solid and reliable clavicular internal fixation would reduce and fix a scapular neck fracture. The scapular neck fracture could achieve general reduction, and the shoulder joint would not be affected directly by surgery. Clavicular fracture surgery for FSI should be differentiated from simple clavicular fracture treatment, and use a plate for fixation; the fixation would thus be firm and resist rotation, and restore the supporting roles. While the Kirschner wire or Ti elastic nail had better advantages in the fields of surgical trauma, complications and shoulder functions [25,26]. Kirschner wire is unable to control rotation, and might move, become loose, exit, angulate, cause malunion and other conditions, and is not used.

Some authors [2,16,22] believe that the long-term outcomes of FSI treatment depend on the reduction quality of the scapular neck fracture; when the clavicular fracture or acromioclavicular joint dislocation obtained stable reduction, not all scapular neck fractures could indirectly achieve accurate reduction. This might be related to some SSSC ligament injuries that lacked early radiographic evidence, but which deserved attention. There were limitations in this study. Because the age range was large, the preoperative shoulder function was unknown. In particular, some elderly patients might have preexisting shoulder disorders, which could affect the results.

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