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Scapulothoracic Abnormal Motion after Conservatively-Treated Clavicular Fractures

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ABSTRACT

Background: Scapulothoracic abnormal motion (STAM), or scapular dyskinesis, can significantly impair shoulder function and is increasingly recognized as a sequela of clavicular fractures. Despite this, its incidence following conservative treatment of clavicle fractures remains under-investigated.

Objective: This study aimed to assess the incidence of scapulothoracic abnormal motion (STAM) after conservative treatment of clavicular fractures.

Patients and methods: A prospective cohort study was conducted from April to September 2024. It involved 21 adult patients with conservatively treated midshaft clavicle fractures at Menoufia University Hospital. Patients were assessed after six months using scapular dyskinesis test, lateral scapular slide test (LSST), Sick Scapula Rating Scale (SSRS), and Simple Shoulder Test (SST). Radiographs were used to evaluate fracture healing.

Results: STAM was identified in 47.6% of patients. mal-union and non-union were significantly associated with STAM ($p = 0.008$). Patients with STAM had significantly worse SSRS scores (6.2 ± 1.1 vs. 3.4 ± 1.1, $p < 0.001$) and lower SST scores (9.2 ± 0.8 vs. 11.45 ± 0.7, $p = 0.002$) compared to those without. No significant associations were found with age, sex, smoking, occupation, or comorbidities.

Conclusion: STAM is a common and clinically significant complication following conservative management of clavicle fractures, particularly in the presence of mal-union or non-union. Early recognition and targeted rehabilitation are essential to optimize shoulder function.

Keywords: Scapular dyskinesis, Clavicle fracture, Scapulothoracic abnormal motion, Non-operative management, Shoulder biomechanics.

INTRODUCTION

Scapulothoracic abnormal motion (STAM), often referred to as scapular dyskinesis, describes an alteration in the normal mobility, mechanics, or function of the scapula. Although it can occasionally be observed in healthy individuals, it is more commonly a secondary manifestation of underlying pathology and is increasingly recognized as a contributor to shoulder pain and dysfunction [(1)].

Shoulder pain is highly prevalent in the adult population, affecting an estimated 4–26% of individuals, with rotator cuff disorders representing the most common etiology. Given the scapula's integral role in coordinating shoulder motion, even subtle deviations from normal scapulothoracic kinematics can significantly impair upper extremity function. The scapula contributes to glenohumeral stability, rotator cuff performance, labral integrity, and maintenance of the subacromial space. Aberrant motion may lead to abnormal joint loading, impingement syndromes, or secondary injury to peri-scapular structures [(2)].

Normal overhead arm elevation requires coordinated upward rotation, posterior tilt, and external rotation of the scapula, movements driven primarily by the trapezius and serratus anterior muscles. Disruption of this rhythm results in altered glenohumeral angulation, acromioclavicular strain, and reduced efficiency of rotator cuff activation. Etiological factors include shoulder-related pathologies (e.g., rotator cuff tears, labral injuries and clavicular fractures), cervical disorders, and postural abnormalities [(3)].

Among these causes, clavicular fractures are of particular relevance. The clavicle serves as the only bony connection between the scapula and the axial skeleton; thus, malunion or shortening may disturb scapulohumeral alignment and scapular motion. Malunited fractures with a shortening of just 15 mm have been demonstrated to induce scapular protraction and anterior tilting, ultimately predisposing to STAM and functional impairment [(4)].

Posterior clavicular rotation allows for initial and final 30° of scapular rotation to accomplish overhead movements [(5)]. Clavicular shortening or malunion alters the clavicle's typical resting position or its capacity to rotate posteriorly with overhead movements [(6)].

An average shortening of 21.4 mm increases upward sterno-clavicular (SC) angulation by 10° and protraction by 6°. Both effects are accompanied by a greater than 10% loss in damaged arm strength for extension, adduction, and internal rotation. The glenoid moves significantly anteromediocaudally when the clavicle shortens [(6)].

Despite the common use of conservative management for midshaft clavicle fractures, evidence suggests that residual deformity and altered biomechanics may contribute to the development of STAM. Understanding the incidence and clinical impact of STAM following non-operative clavicle fracture treatment is therefore essential, as it may guide both therapeutic decisions and rehabilitation strategies [(5)].

The present study aimed to assess the frequency of scapulothoracic abnormal motion in patients with clavicular fractures managed conservatively and to evaluate its association with functional outcomes.

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PATIENTS AND METHODS

This prospective observational study was conducted at the Department of Orthopedics, Menoufia University Hospital between April 2024 and September 2024.

A total of 24 patients with acute midshaft clavicle fractures treated conservatively were initially enrolled. Three patients were excluded due to loss of follow-up, yielding a final study population of 21 patients.

Inclusion criteria: Age ≥18 years, midshaft clavicular fractures treated non-operatively and no prior shoulder/neck trauma.

Exclusion criteria: Shoulder dislocation, prior surgery or injury to the affected shoulder or neck, glenohumeral arthritis, inflammatory arthritis, or nerve injury.

All patients received standard conservative treatment (broad arm sling, analgesics, and anti- edematous medications). At 6 months, clinical assessments included the scapular dyskinesis test, LSST, SSRS and SST. Radiographic evaluation was used to assess union status.

The included patients were subjected to:

I. Detailed history taking that included:

a) Patient age and gender. b) Occupation. c) Affected side. d) Time of trauma. e) Medical comorbidities as (DM, Rheumatoid, …etc.). f) Past history of previous operative procedure of the shoulder and upper limb of interest.

II. Careful clinical examination:

1- <u>General examination for:</u>

- Generalized polyarthritis.
- Ligamentous laxity.
- Generalized joint laxity

2- <u>Local examination for:</u>

- Inspection: Deformity, muscle wasting (posteriorly for cuff & laterally for deltoid), skin condition.
- Palpation: Tenderness.
- Neurovascular examination with examination of axillary nerve, musculocutaneous nerve, long thoracic nerve, radial nerve, median nerve & ulnar nerve, radial artery, ulnar artery.

Special tests:

I) Scapular dyskinesis test (SDT): SDT was developed by McClure in 2009 [7].

Technique:

1. The patient is holding two dumbbells: 1.4kg/3lbs for those weighing less than 68.1kg/150lbs and 2.3kg/5lbs for those weighing more than 68.1kg/150lbs.
2. The patient should complete 5 repetitions of bilateral flexion, followed by 5 repeats of bilateral abduction in the frontal plane, with straight elbows and a cadence of 3 seconds.
3. The examiner checks for winging and dysrhythmia.

Figure (1): Scapular Dyskinesis test by McClure.

II) **Lateral scapular slide test:** The scapular position is calculated by comparing the side-to-side differences between both sides in all three test postures. Measurements are obtained horizontally from the inferior angle of the scapulae to the spinous process of the thoracic vertebrae.

The test is completed in three places. With the arm abducted at 0, 45, and 90 degrees in the coronal plane:

- Position 1 included keeping the shoulder in a neutral position and arms relaxed at the sides.
- In position 2, the humerus is rotated medially and abducted 45 degrees with the patient's hands around the waist.
- In position 3, the humerus is rotated maximally medially and abducted 90 degrees.

The test is positive when bilateral measurements show a 1.5 cm difference.

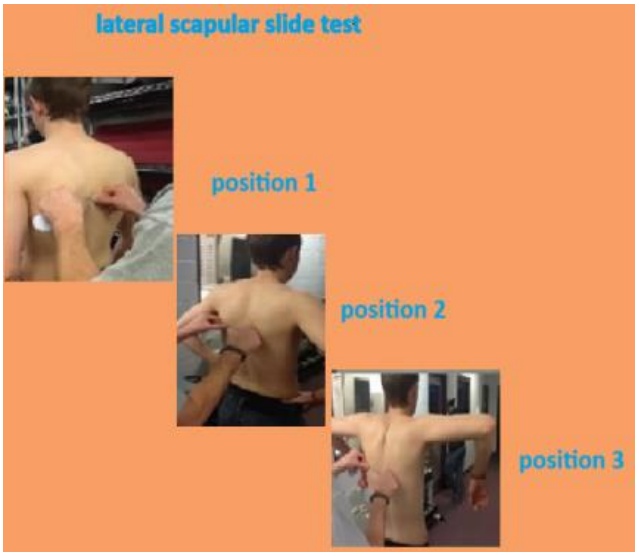

Figure (2): Lateral scapular slide test.

Special scoring systems:

I) **Sick scapula rating score:** It is a 20-points scoring system that helps to rate and evaluate abnormal scapular positioning and movement.

Subjective Pain	No Pain	Yes Pain	
Coracoid	0	1	
AC Joint	0	1	
Periscapular	0	1	
Proximal lateral arm	0	1	
Radicular	0	1	
Objective Test	**Negative**	**Positive**	
Coracoid	0	1	
AC Joint	0	1	
Superomedial scapular angle	0	1	
Th Impingement test	0	1	
Scapular assist test	0	1	
TOS parasthesias	0	1	
Scapular Position			
	0cm	1cm	2cm	3cm
Infera	0	1	2	3
Lateral protraction	0	1	2	3
	0 degrees	5 degrees	10 degrees	15 degrees
Abduction	0	1	2	3

Figure (3): Sick scapula score.

II) **Simple shoulder test score:** It is a-12 item scoring system:

- The minimum score is 0% and the maximum is 100%.
- The items are scored as no=0 and yes=1. To compute the overall score, divide the number of "yes" responses by the number of completed items and multiply by 100 to get the percentage of "yes" responses. 0 represents the poorest function, while 100 represents the greatest.

Simple Shoulder Test

Dominant Hand (fill in only one oval): Right ○ Left ○ Ambidextrous ○

Shoulder Evaluated (fill in only one oval): Right ○ Left ○

	Yes	No
1. Is your shoulder comfortable with your arm at rest by your side?	○	○
2. Does your shoulder allow you to sleep comfortably?	○	○
3. Can you reach the small of your back to tuck in your shirt with your hand?	○	○
4. Can you place your hand behind your head with the elbow straight out to the side?	○	○
5. Can you place a coin on a shelf at the level of your shoulder without bending your elbow?	○	○
6. Can you lift one pound (a full pint container) to the level of your shoulder without bending your elbow?	○	○
7. Can you lift eight pounds (a full gallon container) to the level of your shoulder without bending your elbow?	○	○
8. Can you carry twenty pounds at your side with the affected extremity?	○	○
9. Do you think you can toss a softball under-hand twenty yards with the affected extremity?	○	○
10. Do you think you can toss a softball over-hand twenty yards with the affected extremity?	○	○
11. Can you wash the back of your opposite shoulder with the affected extremity?	○	○
12. Would your shoulder allow you to work full-time at your regular job?	○	○

Figure (4): Simple shoulder test score.

Ethical approval: Ethical clearance was obtained from Menoufia University local Ethics Committee, and informed written consents were obtained from all the patients after explaining the purpose, procedures, and risks of the study. The study adhered to the Helsinki Declaration throughout its execution.

Statistical analysis

SPSS version 25.0 was used for data analysis. When the data satisfied the requirements of normality and homogeneity of variance, the independent t-test was employed to compare the Mean ± SD of continuous variables between two groups. The non-parametric Mann-Whitney U test was used for continuous variables that did not fit these presumptions, especially when sample sizes were small. Categorical variables were analyzed using the X^2-test and Fisher's Exact Test (FET), with the latter being utilized when anticipated cell counts were low. To find determinants of rotation outcome, logistic regression analysis was used. Statistical significance was defined as a significance level of $p \leq 0.05$.

RESULTS

Out of the 21 patients, 10 (47.6%) developed scapulothoracic abnormal motion (STAM). The average age of STAM patients was significantly lower (27.2 ± 6.7 years) compared to those without (35.4 ± 10.5 years), p = 0.049. Clavicle mal-union was significantly more common among patients with STAM (70%) versus 9.1% in the non-STAM group (p = 0.008). Non-union was present in 20% of STAM patients. Functionally, patients with STAM had significantly higher SSRS scores (6.2 ± 1.1) and lower SST scores (9.2 ± 0.8) than those without STAM (SSRS: 3.4 ± 1.1; SST: 11.45 ± 0.7), both p < 0.01. Other variables such as sex, smoking, hand dominance, and occupation were not significantly associated with STAM development. Table (1) displayed the socio-demographic characteristics of the 21 patients included in the study, comparing those with scapulothoracic abnormal motion (Group 1) and those without (Group 2). A statistically significant difference was found in the **mean age**, with group 2 being significantly older than group 1 (35.4 ± 10.5 vs. 27.2 ± 6.7 years, p=0.049). This may suggest that scapulothoracic abnormal motion tends to occur more frequently in younger individuals. No significant differences were observed between groups regarding **gender distribution**, with males representing the majority in both groups (p=1). Similarly, **smoking habits**, **presence of comorbidities** (such as diabetes mellitus), and **occupational exposure** to overhead activities did not differ significantly between the two groups (p>0.05 for all). Additionally, **hand dominance** and **BMI** values showed no statistically significant differences, although group 2 had a slightly higher mean BMI (29.4 vs. 26.4), approaching significance (p=0.076), which may warrant further investigation in larger samples. Overall, aside from age, the sociodemographic characteristics between the two groups were comparable, reducing the potential influence of confounding demographic variables on the clinical findings.

Table (1): Socio-demographic characteristics of studied patients

Sociodemographic characteristics		Total (n=21)		Group1 (n=10)		Group2 (n=11)		Test of sig.	P value
		No.	%	No.	%	No.	%		
Age (years)	Mean ± SD	31.5± 9.6		27.2± 6.7		35.4± 10.5		t=2.99	0.049*
	Range	18-51		18 - 37		22-51			
Gender	Male	14	66.7	7	70.0	7	63.6	FE=0.095	1
	Female	7	33.3	3	30.0	4	36.4		
Smoking habit	Smokers	9	42.9	6	60.0	3	27.7	FE=2.291	0.198
	Non-Smokers	12	57.1	4	40.0	8	72.7		
Comorbidities	None	15	71.4	7	70.0	8	72.7	FE=0.019	1
	DM	6	28.6	3	30.0	3	27.7		
Occupations	Over-head related	7	33.3	3	30.0	4	36.4	FE=0.095	1
	not over-head related	14	66.7	7	70.0	7	63.6		
Dominance	Dominant	15	71.4	6	60.0	9	81.8	FE=1.222	0.361
	Non dominant	6	28.6	4	40.0	2	18.2		
BMI	Mean ± SD	27.9± 3.9		26.4± 3.3		29.4± 4		t=1.877	0.076
	Range	21-35		21-31		21-35			

Table (2) outlined the clinical data of the studied patients, comparing those with scapulothoracic abnormal motion (Group 1) to those without (Group 2). All patients (100%) reported a **history of trauma**, with no differences between the groups (p=1), suggesting trauma as a common etiological factor across the cohort. The **side of involvement** (right vs. left) was also evenly distributed with no significant difference (p=1).

The **lateral scapular slide test (LSST)** revealed a highly significant difference between groups ($p < 0.001$). All patients in group 1 exhibited displacement greater than 1.5 cm, whereas all patients in group 2 showed displacement less than 1.5 cm. This indicates that LSST is a strong discriminative clinical test for scapulothoracic abnormal motion. **Inferior scapular angle prominence** was significantly more frequent in group 1 (60%) compared to none in group 2 (p=0.024), suggesting its clinical relevance in identifying scapular dyskinesis. Although **medial scapular border prominence** was observed in 30% of group 1 and none of group 2.

Clavicle fracture mal-union showed a significant association with scapulothoracic abnormal motion, present in 70% of group 1 and only 9.1% of group 2 (p=0.008). While, **clavicle fracture non-union** showed association with scapulothoracic abnormal motion, present in 20% of group 1 and only 9.1% of group 2. and **scapular superior border elevation** appeared in 10 % of cases. Other variables, including **rotator cuff pathology** (p=0.476), and **previous peri-scapular muscular pathology** (absent in all patients) were not significantly different between the groups.

Table (2): Clinical data of studied patients

Sociodemographic characteristics		Total (n=21)		Group1 (n=10)		Group2 (n=11)		Test of sig.	P value
		No.	%	No.	%	No.	%		
History of trauma	Yes	21	100.0	10	100.0	11	100.0	0	1
	No	0	0.0	0	0.0	0	0.0		
Side	Right	14	66.7	7	70.0	7	63.6	0.095	1
	Left	7	33.3	3	30.0	4	36.4		
Rotator cuff pathology	Yes	2	9.5	0	0.0	2	18.2	2.010	0.476
	No	19	90.5	10	100.0	9	81.8		
Previous peri-scapular muscular pathology	Yes	0	0.0	0	0.0	0	0.0	0	1
	No	21	100.0	10	100.0	11	100.0		
lateral scapular slide test	Less than 1.5 cm	11	52.4	0	0.0	11	100.0	21.0	<0.001**
	more than 1.5 cm	10	47.6	10	100.0	0	0.0		
Inferior scapular angle prominence	Yes	6	28.6	6	60.0	0	0.0	6.109	0.024*
	No	15	71.4	4	40.0	11	100.0		
Medial scapular border prominence	Yes	3	14.3	3	30.0	0	0.0	3.850	0.09
	No	18	85.7	7	70.0	11	100.0		
Scapular superior border elevation	Yes	1	4.8	1	10.0	0	0.0	1.155	0.476
	No	20	95.2	9	90.0	11	100.0		
Clavicle fracture non-union	Yes	3	14.3	2	20.0	1	9.1	0.509	0.586
	No	18	85.7	8	80.0	10	90.9		
Clavicle fracture mal-union	Yes	8	38.1	7	70.0	1	9.1	8.24	0.008*
	No	13	61.9	3	30.0	10	90.9		

Table (3) presented the comparison of clinical scores between patients with scapulothoracic abnormal motion (Group 1) and those without (Group 2), using the sick scapula rating score **(SSRS)** and the simple shoulder test scores **(SSTS)**. There was a **highly significant difference** in the **SSRS** with group 1 (6.2 ± 1.1) scoring significantly higher than group 2 (3.4 ± 1.1), p<0.001. Since a higher SSRS indicated more severe scapular dysfunction, this finding confirmed the presence of substantial scapular impairment in group 1. Similarly, the SSTS was significantly lower in group 1 (9.2 ± 0.8) compared to group 2 (11.45 ± 0.7), p=0.002. As higher SST scores reflect better shoulder function, this suggests that scapulothoracic abnormal motion was associated with notable functional limitations. Overall, both clinical scoring systems effectively differentiated between patients with and without STAM.

Table (3): Clinical scores of studied patients

		Total (n=21)	Group1 (n=10)	Group2 (n=11)	Test of sig.	P value
Sick scapula rating score	Mean ± SD	4.7± 1.8	6.2± 1.1	3.4± 1.1	t=5.758	<0.001**
	Range	2-8	5-8	2-5		
Simple shoulder test scores	Mean ± SD	10.38± 1.4	9.2± 0.8	11.45± 0.7	6.999	0.002**
	Range	8-12	8-10	10-12		

ILLUSTRATIVE CASES

Case I:

- History: Male patient 22-year-old, manual worker presented to the ER after road traffic accident complaining of pain at the right shoulder region.
- Intial x ray:

Figure (5): Case initial X-ray

- The patient followed the conservative management.
- 6 months follow up the patient x-ray showed non-union of the clavicular fracture.

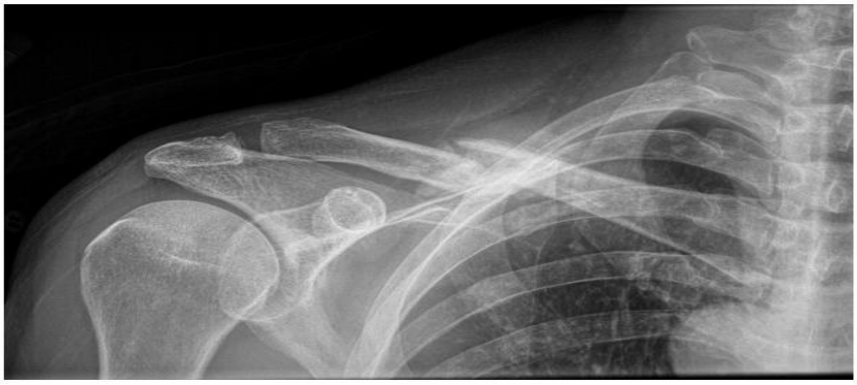

Figure (6): Case 6-months follow up X-ray.

- On examination the patient showed scapulothoracic abnormal motion (with inferior pole prominence)

Figure (7): Case clinical evaluation

- The patient showed:
  - +ve scapular dyskinesis test
  - Sick scapula rating score 9
  - Simple shoulder test scores 8

Case II:

- History: Male patient 24-year-old, college student presented to the ER after falling on his left side, complaining of pain at the left shoulder.
- Intial x ray:

Figure (8): Case II initial X-ray

- The patient followed the conservative management
- 6 months follow up the patient x-ray showed mal-union of the clavicular fracture.

Figure (9): Case II 6-months follow up X-ray

- On examination the patient showed scapulothoracic abnormal motion (with medial wall prominence).

Figure (10): Case II clinical evaluation

- The patient showed:
  - +ve scapular dyskinesis test
  - Sick scapula rating score 8
  - Simple shoulder test scores 8

DISCUSSION

After being an obscure concept for years. Recently there were increasing number of papers, which explained the concept of scapulothoracic abnormal motion (STAM) previously known as scapular dyskinesia. In 2012 **Kibler *et al.*** [6] set a relation between clavicular fractures and scapulothoracic abnormal motion. In 2013 **Kibler *et al.*** [7] not only confirmed the relationship between clavicular fractures and STAM but also explained the clinical implications of scapular dyskinesis in such injury at consensus statement in the second international conference of scapular diseases "scapular summit" held in Lexington Kentucky, USA.

In 2015 **Shields *et al.*** [8] evaluated the incidence of STAM and the ensuing patient outcomes following treatment of isolated, displaced mid-shaft clavicle fractures in skeletally mature patients treated with or without surgery over a 16-month period. He found that a considerable proportion of patients with clavicular fractures experienced poor clinical outcomes and developed STAM. In a recent meta-analysis by **McKee *et al.*** [9], non-operative and surgical therapy for displaced clavicle fractures were compared. The authors discovered a 9% symptomatic malunion rate in the nonoperative group against 0% in the surgical group, as well as differences in related clinical outcomes.

The hypothesis that there is high incidence of TAM after conservatively- treated clavicular fractures was supported by our data. In addition, there was a significant poor clinical outcome in those patients.

This work was a prospective study of twenty-one patients that had clavicular fractures and treated conservatively through pain killers, anti-edematous medications and a broad arm sling during the period from April 2024 till the end of September 2024 with carful history taking and clinical examination and follow up x ray through a period of six months.

The population of our study was relatively homogenous concerning gender, with a predominance of males. The average age was 31.5 years. These characteristics are compatible with world-wide incidence of this fracture. Injuries affected 71.4 % of the dominant side compared to 78 % reported by **Behrend *et al.*** [10].

According to the findings of this investigation, scapulothoracic aberrant motion develops in a considerable percentage of patients (10 patients, or 47.6% of the study population) following displaced middle-third clavicle fractures, compared to 37.5% reported by **Shields *et al.*** [8]**.** In 2015 **Shields *et al.*** [8] reported patients with scapulothoracic abnormal motion had worse SICK scapula scores (5.8±2.2, P=0.01) and worse simple shoulder test scores (10.5±1.6, P=0.029).

Our study showed near results with SICK scapula scores (6.2 ± 1.1, P =0.001), worse SSTS (9.2 ± 0.8, P = 0.002) in patients who developed STAM. While those who didn`t` developed STAM showed excellent clinical outcomes concerning pain, significantly better SICK scapula scores (3.4 ± 1.1, P = .001), and better SSTS (11.45 ± 0.7, P = 0.002).

Ledger *et al.* [11] through an anatomic and functional study reported a link between clavicle mal-union and development of STAM. **Matsumura *et al.*** [12], using cadaveric research, described the effect of clavicle shortening deformity on scapular kinematics. The study employed twelve cadaveric shoulders and reproduced successive clavicular shortening by 0%, 5%, 10%, 15%, and 20% from the original length. Using an electromagnetic tracking device, the scapulothoracic motion during passive arm elevation in three planes was observed. We examined the differences in scapular kinematics between the four experimental groups and the 0% shortening models. When the clavicle was ≥ 10% shorter during arm elevation, the scapula's external rotation and posterior tilting dramatically reduced [12].

In our study we analyzed the data concerning clavicle fracture healing and we found that 9 out of 10 patients with STAM either had mal-union or non-union of the clavicle fracture with a percentage of 70% of mal–union and 20% of non-union in patients with STAM. Leaving only 10% of patients with normal union developed STAM. Surprisingly 9.1% of patients with either mal- or non-union had a perfect scapular motion with near normal clinical outcome concerning pain and scapular scores.

Kibler *et al.* [7] has classified scapular dyskinesis into four categories knowing that class 4 representing the normal symmetrical scapular motion leaving the first 3 classes.

In our study their percentage was as follows:

- **Class one**: Inferior scapular angle prominence represented 60 % of total patients with STAM.
- **Class two**: Medial scapular border prominence represented 30 % of total patients with STAM.
- **Class three**: Scapular superior border elevation represented 10 % of total patients with STAM.

It will continue to be debated whether displaced clavicle fractures can reduce or perhaps prevent scapular dyskinesis. However, according to **Longo *et al.*** [13]**,** surgical fixation lowers a patient's chance of scapular dyskinesis. No other research has demonstrated that surgically fixing these fractures lessens or stops the occurrence of scapular dyskinesis in particular. To verify the advantages of surgery, a larger prospective trial group would be required.

CONCLUSION

STAM is a common and clinically significant complication following conservative treatment of clavicle fractures, particularly when mal-union or non-union occurs. Functional shoulder outcomes were notably impaired in these patients. Early detection and rehabilitation focused on scapular stabilization are essential to optimize recovery.

RECOMMENDATIONS

1. Routine radiographic follow-up for patients with clavicle fractures is essential to identify early mal-union or non-union.
2. Clinical screening using the scapular dyskinesis test and LSST should be implemented post-treatment.
3. Functional outcome measures such as SSRS and SSTS are effective in identifying STAM.
4. Structured physical therapy targeting scapular stabilizers should be initiated early in affected individuals.
5. Further studies comparing surgical and conservative management outcomes in relation to STAM are warranted.

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