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Editorial

The Journal of Southeast Asian Orthopedics has now reached Volume 48: Number 2 (July - December 2024).

The editorial board is very proud of the journal's rapid growth in terms of the number of submissions and the quality of the articles. We would like to thank the reviewers for their consistent efforts in reviewing and improving the articles.

In this issue, there are interesting original articles as well as noteworthy case reports in the field of orthopedics. We promise to strive to maintain the quality of the published articles, ensure fairness in the evaluation process, and maintain promptness in article review.

We thank you once again and invite authors to submit articles for publication consideration in the Journal of Southeast Asian Orthopedics.

Thanainit Chotanaphuti, MD, FRCOST
Editor in chief, Journal of Southeast Asian Orthopaedics
Past President, the RCOST

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Does Adapted Self-Exercise Have Benefits for Stiff Shoulders?

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Purpose: Stiff shoulders restrict shoulder motion and affect the quality of life. Several rehabilitation programs have been implemented to improve these conditions. Various exercises have been designed to achieve positive clinical outcomes. However, too many different sets of exercises can confuse patients and lead to infrequent exercises.

We aimed to compare the clinical outcomes of a small set of adapted self-exercises to a usual set in patients with stiff shoulders.

Methods: Seventy patients with stiff shoulders were randomly assigned to two groups, each performing self-exercises. Self-exercise in group I (the usual set) was composed of 'wall climbing in front,' 'wall climbing at the side,' and 'shoulder stretching with a towel,' and in group II (the adapted set), it was composed of 'assisted forward flexion stretching in the standing position,' 'sleeper stretching in the standing position,' and 'doorway or corner stretching.' The outcome measurements included pain score, functional score, and range of motion.

Results: There were no significant differences in the baseline patient characteristics between the groups in terms of sex (p=0.759), age (p=0.521), underlying disease (p=0.322), or body mass index (BMI) (p=0.687). Group II demonstrated significantly higher improvement in mean pain score decrement (-4.5±1.7 vs. -3.5±2.4, p=0.049), mean ASES score improvement (23.1±9.9 vs. 18.3±13.1, p=0.038) and mean degree improvement of shoulder motion in all directions than in group I.

Conclusions: The adapted self-exercise set may offer favorable results in treating patients with stiff shoulders and may also be a treatment option for overweight patients.

Keywords: Stiff shoulder, Adhesive capsulitis, Frozen shoulder, Sleeper stretch

A common clinical condition is a stiff shoulder, also referred to as adhesive capsulitis or frozen shoulder. This condition restricts shoulder motion and affects the quality of life. The cause of stiff shoulders is not clearly understood, and the exact duration of recovery from this condition is uncertain[2]. Management of stiff shoulders usually begins with nonoperative interventions, including medication, self-stretching exercises, and physical therapy. Different centers have used many rehabilitation programs, and multiple studies have demonstrated improved outcomes[5,7,12,13].

During the COVID-19 pandemic, hospital policies to reduce contamination made treating stiff shoulders more difficult. Self-stretching exercises for improving the mobility of joints and decreasing pain have become a useful treatment. Some studies indicated that self-exercise is more important than

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physical therapy in the hospital, and the effectiveness of self-exercise depends on its frequency(17). In many institutions, a specific group of exercises has been used for patients with stiff shoulders, such as 'wall climbing,' 'shoulder stretching with a towel,' 'sleeper stretching,' 'active assisted shoulder forward flexion with a wand,' 'active assisted shoulder external rotation with a wand,' and 'pendulum exercise,' but no study has demonstrated which exercises are superior(3,5,7,12,13,17). Despite the positive results of many sets of exercises, the large number of self-exercises can be confusing for patients and may result in low compliance. This study used a small set of self-exercises that the physician modified for convenience, called an adapted set.

This study aimed to investigate the benefits of the adapted set of self-exercises in patients with stiff shoulders and demonstrate the better outcome of the adapted set of self-exercises compared to the usual set of self-exercises.

MATERIALS AND METHODS

After receiving approval from our hospital's Ethics Committee, 70 patients were recruited for this study. The inclusion criteria were as follows: 1) age >40; 2) diagnosis of stiff shoulder, adhesive capsulitis, or frozen shoulder; 3) limited range of motion of the shoulder in all directions; 4) consent to be examined by plain radiography; 5) agreement to self-exercise as a treatment for stiff shoulders; and 6) ability to communicate. The exclusion criteria were as follows: 1) history of serious injury or arthrosis of the shoulder, 2) planned pregnancy, 3) serious acute inflammation or infection of the shoulder, 4) bleeding tendency, and 5) inability to participate in the study. A single sports medicine-trained physician participated in this study. The patients were randomly assigned to Groups I and II, alternating according to the order of visits (n=35 in each group). The patients in each group were not informed of the treatment options in the other groups.

Intervention

In this study, self-exercises were selected by using a group of exercises that are commonly used for rehabilitation as home self-exercises, consisting of 'wall climbing in front,' 'wall climbing at the side,' and 'shoulder stretching with a towel,' which are called the usual set and were assigned to group I (Figure 1). Another set of self- exercises was selected by combining three exercises used by sports medicine physicians. To cover shoulder motion, selected self-exercises included 'overhead reach,' 'sleeper stretching,' and 'doorway or corner stretching'(11). In this study, some exercises were adjusted from lying to standing for convenience. Therefore, this set of exercises was called the adapted set and assigned to Group II (Figure 2).

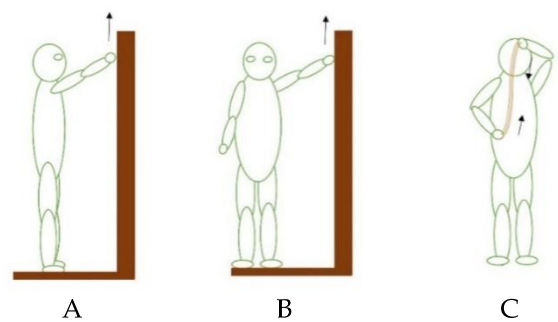

Fig. 1 Exercise in Group I, the usual set: A = wall climbing in front; B = wall climbing at the side; C = shoulder stretching with a towel.

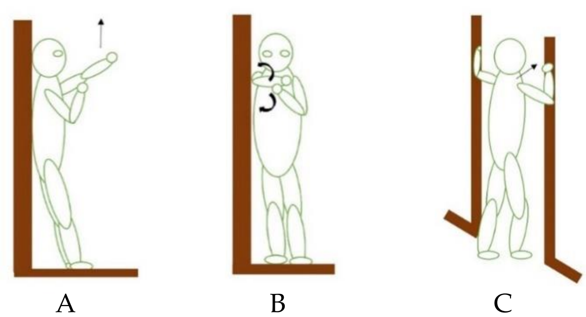

Fig. 2 Exercise in Group II, adapted set: A = assisted forward flexion stretching in the standing position; B = sleeper stretching in the standing position; C = doorway or corner stretching.

The instructions for self-exercise were as follows:

• Wall climbing in front: The patient stands facing a wall. They place the hand of the affected shoulder on the wall and climb as far as possible.

• Wall climbing on the side: The patient stands with the affected shoulder facing the wall.

They place their hand on the wall and climb as far as possible.

• Shoulder stretching with a towel: The patient is standing, and the hand of the opposite shoulder is used to hold the towel behind the back. They should hold the lower end with the hand of the affected shoulder and use the other hand to lift the towel as far as possible (Figure 1).

• Assisted forward flexion stretching in the standing position: The patient stands with their back against the wall, a foot away from the wall, approximately one step. They raise the arm of the affected shoulder upward to the ceiling and use the other hand to push the arm as gently as possible.

• Sleeper stretching in the standing position: The patient stands with the affected side against a wall. They raise the arm straight out from the shoulder, bend the elbow, and maintain it in a L-position. The other hand is used to push the forearm of the affected shoulder up and down toward the wall as far as possible.

• Doorway or corner stretching: The patient stands in an open doorway or corner, raising each arm to the side and bent at 90-degree angles with the palms on the door frame or wall. They slowly step forward with one foot and feel the stretch of the shoulders (Figure 2).

The participants were held at the farthest point of each exercise for 20 s. This was repeated ten times per session for six sessions per day. Each patient was given a pamphlet with instructions for self-exercise and received coaching from a physician. In both groups, nonsteroidal anti-inflammatory drugs or analgesics were prescribed as necessary.

Outcome Measurements

All patients were re-examined at one-month intervals for up to three months. At each visit, the physician reassessed the set of exercises, pain scores, shoulder function, and passive shoulder range of motion. Shoulder function was assessed using the Thai version of the ASES (American Shoulder and Elbow Surgeons) Score, which is reliable[14]. In the standing position, the shoulder range of motion was assessed by asking the patient to move the arm in the desired direction and verifying the absence of muscle weakness by having the examiner push the arm further in that direction. A universal goniometer is then used to measure multiple directions, such as forward flexion, abduction, adduction, extension, internal rotation, and external rotation of the side [6,9]. Data on pain, ASES score, and range of motion were used for outcome analysis.

The primary endpoints were the effects of two small sets of self-exercises on pain, shoulder function (ASES score), and range of motion. The secondary endpoint was the relationship between patient characteristics regarding pain, shoulder function, range of motion, and self-exercise.

Sample Size

The sample size was calculated by using GPower to estimate the sample sizes for a two-sample means test using α= 0.05, the power of the test= 80%, the confidence level= 95%, mean1= 0.80, mean2= 0.10, and the standard deviation= 1.00. The minimum sample size was 34 patients in each group (at least 68 patients). Data were analyzed using SPSS, Inc., released in 2009, PASW Statistics for Windows, Version 18.0. Chicago: SPSS, Inc. An independent t-test was used to compare differences in the change in pain scores between the two groups. A dependent t-test was used to compare differences in pain scores between the initial and final measurements. Multivariate analysis was used to analyze the relationship between the delta ASES score and the variables, delta pain, and the variables in the Gaussian regression model. The chi-square test was used to compare significantly different baseline characteristics between the two groups. $P < 0.05$ was considered to indicate statistical significance.

RESULTS

Seventy patients (57 women, 13 men) were enrolled in this study. None of the patients were lost to follow-up. According to the demographic data analysis, there was no significant difference between the usual-set and adapted-set groups in baseline characteristics such as sex (p=0.759), age (p=0.521), BMI (p=0.687), handedness (p=0.555), and underlying diseases, such as diabetes (p=0.607), hypertension (p=0.803), and dyslipidemia (p=0.051) (Table 1).

The baseline pain score in group II was significantly higher than in group I (p=0.046). The ASES score was significantly higher in group II (p=0.043). The baseline shoulder range of motion showed no significant difference, except for extension, which was significantly lower in group II (p=0.006).

After intervention, the mean pain score significantly decreased in both groups. The pain score in group I decreased from 6.3 ± 2.1 to 2.8 ± 1.8 (p<0.001), and that in group II decreased from 7.1 ± 1.5 to 2.7 ± 1.2 (p<0.001). However, the mean pain score decrement in group II (-4.5 ± 1.7) was significantly better than in group I (-3.5 ± 2.4) (p=0.049) (Table 2). The ASES score also demonstrated significant improvement in group I (from 41.1 ± 2.6

Table 1 Baseline characteristics of patients in the study between groups by set of self-exercises.

	Group I (usual set)		**Group II (adapted set)**		**p-value**
	(n = 35)	**(%)**	**(n = 35)**	**(%)**	
Gender					0.759
Male	6	17.1	7	20.0	
Female	29	82.9	28	80.0	
Handedness					0.555
Right	34	97.1	33	94.3	
Left	1	2.9	2	5.7	
Affected shoulder					0.094
Right	13	37.1	20	57.1	
Left	22	62.9	15	42.9	
Underlying disease					0.322
Yes	20	57.1	24	68.6	
No	15	42.9	11	31.4	
Diabetes	10	28.6	12	34.3	0.607
Hypertension	13	37.1	12	34.3	0.803
Dyslipidemia	10	28.6	18	51.4	0.051
Kidney disease	1	2.9	0	0	0.314
Age (min–max) (yrs.)	44 – 79		43 – 75		
$\bar{x}$ ± SD	61.2 ± 9.1		59.8 ± 8.7		0.521
<65 yrs.	22	62.9	24	68.6	0.615
≥65 yrs.	13	37.1	11	31.4	
Body Mass Index (BMI) (kg/m2)	19.3 – 33.9		19.0 – 35.8		
$\bar{x}$ ± SD	25.9 ± 3.7		25.5 ± 4.3		0.687
< 23	6	17.1	11	31.4	0.163
≥ 23	29	82.9	24	68.6	
Pain score					
$\bar{x}$ ± SD	6.3 ± 2.1		7.1 ± 1.5		0.046*
ASES score					
$\bar{x}$ ± SD	41.1 ± 15.8		48.1 ± 12.5		0.043*
Range of motion of affected shoulder ($\bar{x}$ ± SD)					
Forward flexion	90.3 ± 21.3		96.4 ± 23.2		0.260
Abduction	64.7 ± 16.6		73.5 ± 25.7		0.092
Adduction	13.2 ± 9.7		14.5 ± 9.9		0.593
Extension	33.5 ± 9.1		27.9 ± 7.4		0.006*
Internal rotation	35.6 ± 12.5		35.2 ± 13.8		0.899
External rotation	29.1 ± 16.8		31.7 ± 14.2		0.482

*p<0.05, considered statistically significant to 59.3 ± 13.6) and group II (from 48.1 ± 12.5 to 71.2 ± 10.8) ($p<0.001$). Nevertheless, group II showed a significantly higher mean ASES score improvement ($p=0.038$) than group I (Table 3).

Both groups showed significant improvements in the range of motion in forward flexion, abduction, adduction, extension, internal rotation, and external rotation ($p<0.001$). Compared with group I, group II showed a significantly higher mean degree of improvement in all directions ($p\leq0.001$) (Table 4)

Table 2 Pain score improvement between groups by set of self-exercises.

	Group	Within group			Between group	
		Pre ($\bar{x}$ ± SD)	Post ($\bar{x}$ ± SD)	p-value	Mean pain score decrement	p-value
Pain score	I (usual set)	6.3 ± 2.1	2.8 ± 1.8	p<0.001*	-3.5 ± 2.4	p=0.049*
	II (adapted set)	7.1 ± 1.5	2.7 ± 1.2	p<0.001*	-4.5 ± 1.7	
		p=0.046*	p=0.758			

*p<0.05, considered statistically significant

Table 3 ASES score improvement between groups by set of self-exercises.

	Group	Within group			Between group	
		Pre ($\bar{x}$ ± SD)	Post ($\bar{x}$ ± SD)	p-value	Mean ASES score improvement	p-value
ASES score	I (usual set)	41.1 ± 2.6	59.3 ± 13.6	p<0.001*	18.3 ± 13.1	p=0.038*
	II (adapted set)	48.1 ± 12.5	71.2 ± 10.8	p<0.001*	23.1 ± 9.9	
		p=0.043*	p<0.001*			

*p<0.05, considered statistically significant

Table 4 Range of motion improvement between groups by set of self-exercises.

	Group	Within group			Between group	
		Pre ($\bar{x}$ ± SD)	Post ($\bar{x}$ ± SD)	p-value	Mean degree improvement	p-value
Forward flexion	I (usual set)	90.3 ± 21.3	111.2 ± 20.7	p<0.001*	20.9 ± 13.5	p<0.001*
	II (adapted set)	96.4 ± 23.2	139.2 ± 24.9	p<0.001*	42.9 ± 21.2	
Abduction	I (usual set)	64.7 ± 16.6	85.3 ± 24.3	p<0.001*	20.6 ± 15.7	p<0.001*
	II (adapted set)	73.5 ± 25.7	125.7 ± 26.9	p<0.001*	52.2 ± 28.3	
Adduction	I (usual set)	13.2 ± 9.7	21.5 ± 10.6	p<0.001*	8.3 ± 6.7	p=0.001*
	II (adapted set)	14.5 ± 9.9	30.9 ± 9.7	p<0.001*	16.5 ± 11.7	
Extension	I (usual set)	33.5 ± 9.1	42.5 ± 9.4	p<0.001*	9.0 ± 8.1	p<0.001*
	II (adapted set)	27.9 ± 7.4	45.7 ± 5.2	p<0.001*	17.8 ± 7.8	
Internal rotation	I (usual set)	35.6 ± 12.5	47.9 ± 13.4	p<0.001*	12.3 ± 8.0	p<0.001*
	II (adapted set)	35.2 ± 13.8	58.6 ± 8.1	p<0.001*	23.4 ± 10.8	
External rotation	I (usual set)	29.1 ± 16.8	44.5 ± 18.8	p<0.001*	15.5 ± 11.2	p=0.001*
	II (adapted set)	31.7 ± 14.2	57.9 ± 15.7	p<0.001*	26.3 ± 13.6	

*p<0.05, considered statistically significant

Table 5 Comparison between groups by set of self-exercise, subclassified by BMI, gender, age, and affected shoulder.

	Group	Mean pain score decrement	Mean ASES score improvement	Range of motion (Mean degree improvement)					
				Forward flexion	Abduction	Adduction	Extension	Internal rotation	External rotation
BMI<23	I (usual set) (N=6)	-3.7±1.5	18.3±7.5	15.3±18.6	20.0±19.6	10.2±9.0	5.0±9.3	9.5±11.5	8.8±11.1
	II (adapted set) (N=11)	-3.9±1.6	20.3±9.5	44.8±19.8	53.4±22.1	14.6±8.6	15.8±7.9	22.4±10.6	25.6±12.2
	p-value	p=0.769	p=0.673	p=0.009*	p=0.008*	p=0.329	p=0.023*	p=0.035*	p=0.014*
BMI≥23	I (usual set) (N=29)	-3.5±2.5	18.3±14.1	22.1±12.3	20.8±15.2	7.9±6.3	9.9±7.7	12.9±7.3	16.9±10.8
	II (adapted set) (N=24)	-4.8±1.8	24.4±10.0	42.0±22.2	51.7±31.2	17.3±13.0	18.7±7.7	23.9±11.0	26.6±14.5
	p-value	p=0.039*	p=0.081	p<0.001*	p<0.001*	p=0.001*	p<0.001*	p<0.001*	p=0.007*
Male	I (usual set) (N=7)	-2.9±3.8	14.3±18.8	20.6±17.0	16.6±19.5	7.4±6.8	8.3±8.3	14.3±8.3	16.4±14.6
	II (adapted set) (N=6)	-5.0±1.3	27.5±11.7	61.0±21.4	63.3±18.1	15.5±22.1	19.8±6.5	27.5±11.4	33.7±6.6
	p-value	p=0.212	p=0.165	p=0.003*	p=0.001*	p=0.375	p=0.019*	p=0.034*	p=0.022*
Female	I (usual set) (N=28)	-3.6±2.0	19.3±11.5	21.0±12.8	21.6±14.9	8.5±6.8	9.2±8.2	11.8±8.1	15.3±10.5
	II (adapted set) (N=29)	-4.4±1.8	22.2±9.5	39.1±19.5	49.9±29.7	16.7±8.9	17.4±8.0	22.6±10.7	24.7±14.3
	p-value	p=0.148	p=0.305	p<0.001*	p<0.001*	p<0.001*	p<0.001*	p<0.001*	p=0.006*
Age<65 yrs.	I (usual set) (N=22)	-3.8±1.9	20.5±11.4	19.4±13.5	23.6±13.8	9.6±6.8	10.6±7.4	12.2±8.2	15.1±11.9
	II (adapted set) (N=24)	-4.8±1.7	24.3±8.9	44.7±23.5	53.7±30.8	19.5±8.7	18.7±8.8	24.4±10.4	26.3±13.8
	p-value	p=0.072	p=0.210	p<0.001*	p<0.001*	p<0.001*	p=0.002*	p<0.001*	p=0.006*
Age≥65 yrs.	I (usual set) (N=13)	-2.9±3.1	14.6±15.3	23.5±13.6	15.7±18.1	6.1±+6.1	6.3±8.8	12.5±8.2	16.1±10.4
	II (adapted set) (N=11)	-3.8±1.7	20.5±11.7	38.9±15.3	48.9±22.9	9.7±14.8	15.9±4.7	21.2±11.9	26.3±14.0
	p-value	p=0.397	p=0.313	p=0.016*	p=0.001*	p=0.426	p=0.004*	p=0.045*	p=0.053

*p<0.05, considered statistically significant

According to the BMI criteria for Asians, patients in both groups were divided into normal weight (BMI <23 kg/m^2) and overweight (BMI ≥23 kg/m^2) subgroups[10]. Group II showed a significant decrease in the pain score compared to group I in patients with BMI ≥23 kg/m^2 (p=0.039). It also showed a significant improvement in range of motion in patients with a BMI ≥23 kg/m^2, which was better than that in those with a BMI <23 kg/m^2.

There were no significant differences between males and females. It also showed no difference between the patients who were <65 and ≥65.

DISCUSSION

This study investigated the effects of a small group of exercises on patients with stiff shoulders. Seventy patients were divided into two groups, and a small set of self-exercises was assigned to each group: the usual set for Group I and the adapted set for Group II. In both groups, a small set of self-exercises produced significantly better results regarding pain score, functional score, and shoulder range of motion. In group II, significant improvements in pain score (p=0.049), functional score (p=0.038), and shoulder range of motion (p≤0.001) were observed compared with group I. This may be due to self-exercise patterns. The assisted passive stretching exercise in Group II may have a better effect on the stretching of the joint capsule than the exercise in Group I. Wall climbing in front and wall climbing at the side in Group I may involve moving the body to help raise the arms higher more than moving the shoulder joint alone. While the assisted forward flexion stretching in Group II, which involves standing with the back to the wall, may assist in preventing the body from moving, the shoulder joint may stretch more as a result of this than it did in Group I. Sleeper stretching helped to improve range of motion by stretching the posterior capsule and musculature, according to a study by Laudner *et al*.[8], and doorway stretching stretched the structure on the front of the shoulder joint.

Sleeper stretching has shown significant improvement in range of motion and is advantageeous for treating stiff shoulders. Chidambaram *et al*. reported that sleeper stretching and manual mobilization improved range of motion and pain scores[4]. Sule *et al.* demonstrated that sleeper stretching performed by therapists improved shoulder ranges of flexion, extension, internal rotation, and adduction but did not improve pain and function[16]. Sleeper stretching was limited by the space required because it had to be performed in a lying position. In this study, the pattern of self-exercise in Group II was adapted to be more convenient by adjusting the overhead reach and sleeper stretching exercise from a lying position to a standing position, demonstrating a better result than in Group II.

Subgroup analysis revealed that the adapted set of exercises had better effects than the usual set in patients with a BMI ≥23 kg/m^2 in terms of pain score, functional score, and shoulder range of motion. A thick torso may impede certain self-exercises in the overweight group, such as shoulder stretching with a towel. This is because, at the beginning of the exercise, the hand of the affected shoulder must be placed behind the back. Therefore, sleeper stretching in the standing position, which puts the arm in front, maybe more advantageous. Barbosa et al. reported that 53% of patients with a BMI >30 did not respond to conservative treatment and underwent arthroscopic surgery[1]. No studies have focused on the effects of self-exercise in patients with obesity. According to the findings of this study, the adapted set of self-exercises improved pain, range of motion, and shoulder function, and patients with a BMI ≥23 kg/m^2 benefited from the adapted set of self-exercises.

This study had some limitations. First, a small number of patients treated by a single physician may not represent the general Thai population. Secondly, the physicians who treated the patients were not blinded to the study.

CONCLUSIONS

According to the findings, the adapted self-exercise set may offer favorable results in treating patients with stiff shoulders and may also be a treatment option for overweight patients.

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Association Between Sarcopenia and Functional Independence After Acute Fragility Hip Fracture at 6 Months

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Purpose: The primary goal of hip fracture treatment is to allow ambulatory life as early as possible to avoid any subsequent complication after fracture. The European Working Group on Sarcopenia in Older People (EWGSOP) defined sarcopenia as the presence of both low muscle strength and low muscle quantity. Our purpose in this study was to identify the association between sarcopenia and functional independence after acute fragility hip fracture.
Methods: Patients 50 years old or more without neurologic diseases who encountered fragility hip fracture for the first time were included. Sarcopenia was assessed using EWGSOP revised 2018 criteria. Functional independence was assessed using the Barthel Index (BI) at 6 months after injury. Data were analyzed using multiple linear regression.
Results: A total of 240 patients were included; overall, 84 patients with and 156 without sarcopenia. Multiple linear regression analysis showed significant difference in BI at 6 months among those with and without sarcopenia (p<0.001). Specifically, the lower limb related components of BI were decreased four points in patients with sarcopenia, which is a more statistically significant result when compared to the overall BI score.
Conclusions: In this study, patients with sarcopenia were associated with functional independence impairment. Lower limb-related components of the BI must be specifically assessed in patients with hip fracture. Moreover, rehabilitation programs should be tailored to the specific needs of the patient.

Keywords: sarcopenia, hip fracture, prevalence, outcome

Hip fracture is common among older adults. Apart from healing the injury, returning the patient back to functional independence is the ultimate goal. With increase in age, muscle mass and quality change significantly. After about 50 years of age, muscle mass decreases at an annual rate of 1–2%. The decline in muscle strength is even higher, amounting to 1.5% per year between ages 50 and 60 years and 3% per year thereafter[1,2]. In 2018, the European Working Group on Sarcopenia in Older People (EWGSOP) redefined sarcopenia as presence of both low muscle strength and low muscle quantity or quality (Fig.1). Muscle strength

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is measured using grip strength or chair stand test. Conversely, muscle quantity, the appendicular skeletal muscle mass (ASMM), is measured using Dual-energy X-ray absorptiometry (DXA)[3]. Recent studies found that sarcopenia was present at a rate of up to 58% in patients with hip fracture and associated with falls and fractures, affecting the functional outcome and mortality in geriatric populations[4,5].

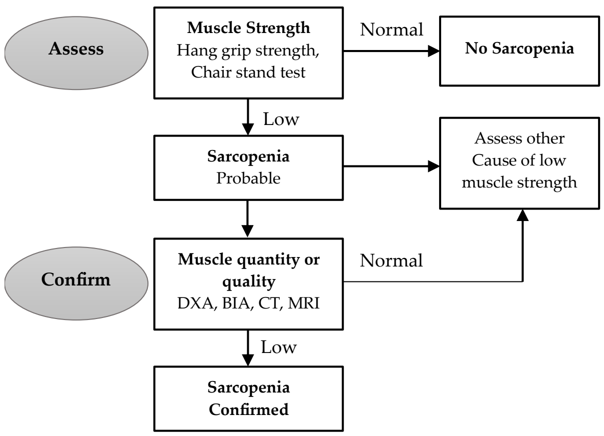

Fig. 1 Diagnosis of sarcopenia.
(From: Sarcopenia: revised European consensus on definition and diagnosis 2018. Age and Ageing. 2019)

The return of the patient to the community requires adequate functional independency, which is generally assessed using the Barthel Index (BI)[6-8]. The BI comprises 10 components, of which 6 are related to the activities that use more lower limb functions. Those are bed or chair transfer, toilet use, mobility on level surface, dressing, climbing stairs, and bathing. We wondered whether the lower extremity-related components of Bathel Index (BI) would provide a clearer picture of the patients' functional independency. Therefore, BI components were divided into two groups; those with lower extremity-related Barthel Index (LER-BI) and those with non-lower extremity related Barthel Index (non-LER-BI).

We aimed to identify the association between sarcopenia and the lower extremity-related functional independency of patients after acute fragility hip fracture.

METHODS

Patients aged 50 years or older with a diagnosis of acute fragility hip fracture, admitted in our hospital between April 2019 and January 2021, were included. The patients who had motor impairment from neurologic diseases, previous history of hip fractures, and incomplete data were excluded.

Data from medical records including sex, age, body mass index (BMI), ASMM by DXA, and handgrip strength during hospitalization for the treatment of hip fracture were collected.

Sarcopenia is defined as low muscle strength along with low muscle quantity. The muscle strength was measured using handgrip strength with Exacta Hydraulic Hand Dynamometer and performed with the Southampton protocol[9]. According to the revised EWGSOP 2018 criteria, handgrip strengths of <27 kg in male patients or <16 kg in female patients were used as cut-off points for low muscle strength. The ASMM measured using DXA was used as the indicator for the loss of muscle quantity. The ASMM results of <7.0 kg/m^2 in male patients or <5.5 kg/m^2 in female patients were used as cut-off points for low muscle quantity. We classified patients into two groups, non-sarcopenia and sarcopenia. According to EWGSOP 2018, patients who had both low muscle strength and low muscle quantity to the aforementioned level were classified as having sarcopenia[3].

Functional independence was assessed using BI at 6 months after injury. The Thai-version of BI, which yields good validity and reliability, was used[10]. Subgroup analysis of LER-BI and non-LER-BI were recorded.

Baseline characteristics were described as mean with standard deviation and frequency. Multiple linear regression analysis was used to identify the primary outcome with statistical significance at p-value <0.05. The independent variables were sarcopenia, sex, age, and BMI. The dependent variable was BI. STATA, version 16, was used for statistical analysis.

RESULTS

There were 375 consecutive patients treated in the hospital, of which 135 were excluded. Of the 245 patients included (Fig. 2), 76 male and 164 female and 156 (65%) did not have sarcopenia while 84 (35%) had sarcopenia. The mean age was 75.6 (50-93) years old. Overall, 10 (42.1%) patients had close intertrochanteric fracture and 139 (57.9%) had close femoral neck fracture.

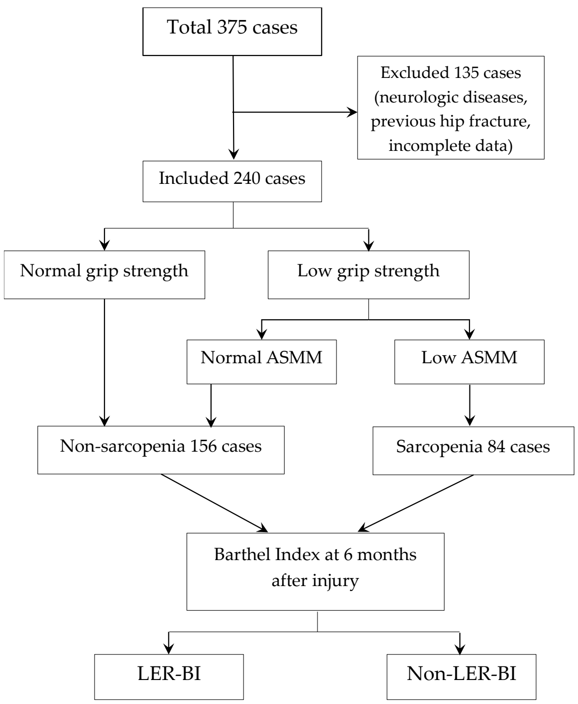

Fig. 2 Study flow chart.

Table 1 Demographic characteristics of the study population (N=240).

	Women	Men
n	164	76
Age	79.6 ± 16.8	71.5 ± 15.4
Body weight, kg	54.9 ± 11.9	68.6 ± 11.4
Height, m	1.53 ± 0.08	1.67 ± 0.07
Body mass index, kg/m²	23.5 ± 4.7	25.2 ± 3.4
Body fat, %	33.3 ± 9.3	21.1 ± 8.8
Fat free body mass, kg	35.3 ± 5.3	39.3 ± 7.5
Appendicular skeletal muscle, kg		
Total	17.6 ± 2.6	27.3 ± 3.9
Leg	13.8 ± 1.9	20.6 ± 2.8
Arm	3.8 ± 1.0	6.7 ± 1.5
Appendicular skeletal muscle mass (ASMM), kg/m²	5.4 ± 1.1	7.5 ± 1.7
Hand grip strength, kg	16.7 ± 3.6	28.9 ± 4.5

Univariate analysis showed a statistically significant difference between the mean BI of patients without sarcopenia (mean ± SD = 17.70 ± 1.62) and that of those with sarcopenia (mean ± SD = 13.34 ± 2.01), ($p<0.001$) (Fig.3). Furthermore, the difference between the LER-BI of those without sarcopenia (mean ± SD = 10.94 ± 1.42) and that of those with sarcopenia (mean ± SD = 7.02 ± 1.62), ($p<0.001$) was significantly different. There was also a statistically significant difference between the mean non-LER-BI of those without sarcopenia (mean ± SD = 6.76 ± 0.51) and that of those with sarcopenia (mean ± SD = 6.32 ± 0.80), ($p<0.001$) (Fig.4).

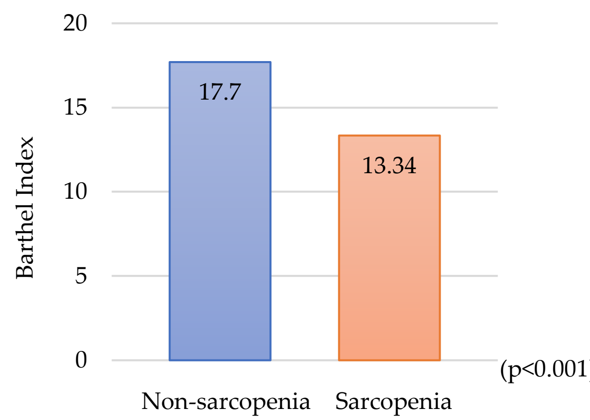

Fig. 3 Difference in mean BI between groups.

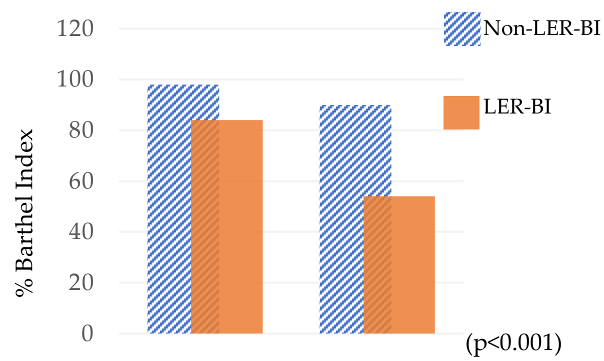

Fig. 4 Difference in non-LER-BI and LER-BI between groups.

Multiple linear regression analysis showed a significant association between BI at 6 months after injury and sarcopenia, sex, age, and BMI. Compared to those without sarcopenia, the BI was four points lower in those with sarcopenia (p<0.001). The BI was also found to be decreased by one point in the female group (p=0.027). Details of the outcomes are shown in table 2.

Subgroup analysis, focusing on the lower limb related activities, showed that the BI was significantly lower in those with sarcopenia compared to those without, 13.3 vs 17.7 (p<0.001)(Fig.3). Compared to the non-sarcopenia group, the mean LER-BI was four points lower (p<0.001) (Table 3) and the mean non-LER-BI was 0.4 points lower (p=0.002) in those with sarcopenia compared to those without (Table 4).

Table 2 Multiple linear regression analysis: Barthel Index assessed at 6 months after injury.

Variables	Coefficient	p-Value	95% CI
Sarcopenia	-4.08	<0.001	-4.74 -3.42
Sex			
Female	-0.81	0.027	-15.2 -0.09
Age	-0.05	0.004	-0.08 -0.01
Body mass index	0.11	0.007	0.03 0.18

Statistically significant at p<0.05

Table 3 Subgroup analysis: Lower Extremity related Barthel Index (LER-BI) at 6 months after injury.

Variables	Coefficient	p-Value	95% CI
Sarcopenia	-3.68	<0.001	-4.24 -3.12
Sex			
Female	-0.62	0.045	-1.23 -0.02
Age	-0.04	0.009	-0.06 -0.01
Body mass index	0.10	0.004	0.03 0.16

Statistically significant at p<0.05

Table 4 Subgroup analysis: Non-Lower Extremity related Barthel Index (non-LER-BI) at 6 months after injury.

Variables	Coefficient	p-Value	95% CI
Sarcopenia	-0.40	0.002	-0.65 -0.15
Sex			
Female	-0.19	0.175	-0.46 0.08
Age	-0.01	0.084	-0.02 0.001
Body mass index	0.01	0.491	-0.02 0.04

Statistically significant at p<0.05

DISCUSSION

Several factors affect the recovery of patients with acute hip fracture. Sarcopenia indicates the muscle strength and muscle quantity and is now generally accepted as one of the major predictors of functional outcomes in older people. Therefore, assessing sarcopenia in every patient with hip fracture is crucial for the assessment of the correct prognosis and maximization of the recovery program of a patient at risk. This study showed a deficiency of the functional independence among patients with hip fracture related to the existence and degree of the sarcopenia.

The difference in the mean of BI among those with and without sarcopenia was more pronounced when the lower extremity related components of the BI was considered. However, the total BI score itself was not as significant or meaningful as the breakdown into individual items since these indicate where the deficiencies were.

Assessment of LER-BI seemed precise and time-effective in the evaluation of the patient post-fracture. A rehabilitation program tailored specifically to the deficiencies of the patient with hip fracture would be more useful and applicable. A scheme to follow patients' progression in the rehabilitation program can be planned. This strategy can lead to a more positive post-fracture functional outcome.

A limitation of this study was that it was a single-center study with one protocol for post-fracture rehabilitation for all hip fracture patients that might not be generalizable to the overall population of patients with hip fractures. To define sarcopenia using grip strength as the muscle strength measuring tool might not directly measure the affected part. However, the chair stand test, which is the other option to assess muscle strength could not be used due to the hip fracture. We used EWGSOP 2018 criteria instead of Asian working group for sarcopenia, AWGS 2019 due to the late launch of AWGS after our research was conducted. However, the cut-off values of these two criteria for the hand grip and the ASMM are quite similar, that is <27 kg in men and <16 kg in women for EWGSOP 2018 and <28 kg in men and <18 kg in women for AWGS 2019. ASMM cut-off values are <7.0 kg/m^2 in men and <5.5 kg/m^2 in women for EWSGOP 2018 and <7.0 kg/m^2 in men <5.4 kg/m^2 in women for AWGS 2019.

CONCLUSIONS

Sarcopenia was associated with the impairment of the patient's functional independence after acute hip fracture. When assessing a patient with hip fracture, there should be a focus on the lower limb related components of the BI. A rehabilitation program can be tailored to the specific impaired site and needs of the patient.

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Comparative Study of Union Rate in Closed Humerus Shaft Fracture After Operative Fixation with Anteromedial Versus Anterolateral Surface Plating Using the Anterolateral Approach: A Randomized Controlled Study

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Purpose: Plate osteosynthesis is considered the gold standard for treating humeral shaft fractures, and orthopedic surgeons widely use the anterolateral approach with anterolateral surface placement. However, surgeons may have difficulties with the non-smooth surface and proximity to the radial nerve during their use. To address this challenge, we propose introducing the anterolateral approach with anteromedial surface placement. This study aimed to compare the outcomes between anteromedial and anterolateral surface plating using the anterolateral approach.
Methods: This study included 74 patients who sustained a mid-shaft humerus fracture (AO 12) and underwent open reduction internal fixation between December 2020 and December 2022. Twelve patients were excluded based on the exclusion criteria. Among the remaining patients, 30 were randomized and allocated to surgery with anteromedial surface plating, while 32 patients were treated with anterolateral surface plating through an anterolateral approach. Postoperative clinical and radiographic results were recorded and analyzed.
Results: The union rate, blood loss, operative time, and complications were not significantly different between the two groups. All the patients healed radiographically except for two in the anterolateral surface plating group, who required reoperation. Although anteroposterior alignment was significantly better in the anteromedial surface plating group, it was not clinically significant.
Conclusions: Anteromedial plating demonstrated a commendable union rate, offered assured alignment, and presented itself as a secure option for addressing fractures of the humerus shaft.

Keywords: Humerus, Humerus shaft fracture, Anteromedial plating, Anterolateral plating, Anterolateral approach

Humeral shaft fractures represent approximately 1–3% of all fractures[1]. Conservative treatment remains the mainstay for isolated humeral shaft fractures, yielding generally favorable outcomes[2]. Nevertheless, non-surgical approaches are linked to certain morbidities and complications, including nonunion, which has been reported to be as high as 25% in some studies, malunion, and persistent radial nerve deficits[3]. Surgical treatment becomes necessary in specific circumstances, including open fractures, associated neurovascular injuries, floating elbow, pathologic fractures, and

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instances where non-operative management has proven ineffective. Surgical options encompass plate osteosynthesis, intramedullary nailing, or external fixation. Plate fixation remains the preferred method for surgically managing humeral shaft fractures due to its superior biomechanical properties in resisting anti-torsional forces(4). The anterolateral surface plating, employed through an anterolateral approach, is widely utilized. However, the consideration of anteromedial surface plating, a less commonly discussed alternative, for humeral shaft fracture management is relatively rare(5-8).

The anteromedial surface plating method has demonstrated numerous advantages for managing humeral mid-shaft fractures. One notable benefit is the plate's noninterference with the radial nerve, with no requirement to anatomically prebend the plate due to the smooth, bony surface(9).

This study primarily aimed to investigate the outcomes related to the union rate. The secondary objective was to assess operative time, blood loss, alignment, and complications associated with the fixation of humeral mid-shaft fractures. We compared the anteromedial and anterolateral surface plating methods using an anterolateral approach.

MATERIALS AND METHODS

Selection of Patients

This randomized controlled study included 74 patients who sustained a humerus shaft fracture and underwent open reduction and internal fixation in our institute between December 2020 and December 2022, following approval by our local ethics committee. The inclusion criteria were a closed mid-humeral shaft fracture (AO 12), patients aged 20–60 years, and those who underwent surgery within 2 weeks after the initial injury. The exclusion criteria were an open fracture, vascular injury, radial nerve injury, pathological fracture, and ipsilateral upper limb injury (Fig. 1).

Informed consent was obtained from all the patients before inclusion in the study. The procedure was randomized using sealed envelopes in blocks of four to select the techniques of fixation. The envelopes were opened before making any skin incisions. The anterolateral approach was employed for all patients, with anteromedial and anterolateral surface plating for 30 and 32 patients, respectively. A senior trauma surgical team conducted all procedures. Table 1 presents the demographic data of the patients.

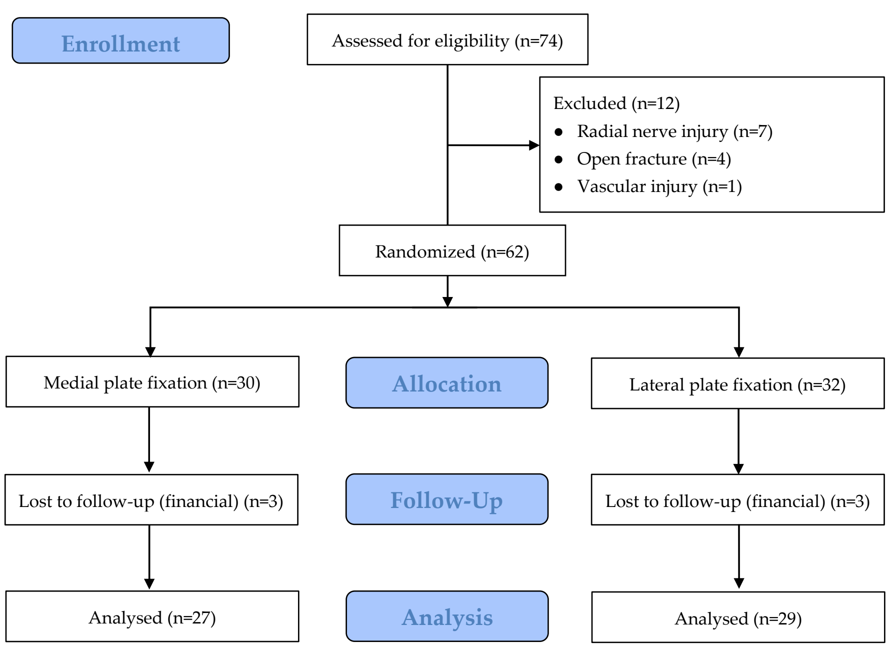


Fig. 1 CONSORT flow diagram.

Table 1 Baseline characteristics of the patients.

	Anteromedial plating group	Anterolateral plating group	p-value
Patient, n	30	32	
Gender, n (%)			
Male	19 (63.33)	24 (75.00)	0.319
Female	11 (36.67)	8 (25.00)	
Age, mean (SD)	38.93 (12.83)	35 (10.93)	0.198
Smoking status, n (%)	13 (43.33)	16 (50.00)	0.599
Mechanism of injury, n (%)			
Traffic accident	21 (70.00)	24 (75.00)	0.659
Fall from height	9 (30.00)	8 (25.00)	
Fracture type (AO/OTA Classification), n (%)			
Type A	10 (33.33)	15 (46.88)	0.419
Type B	19 (63.33)	15 (46.88)	
Type C	1 (3.33)	2 (6.25)	

Surgical Techniques

Anteromedial Surface Plating

Patients were placed in the supine position on a radiolucent table with the arm in abduction on an arm board after the induction of general anesthesia, and the entire limb was prepared, exposing the shoulder and elbow. The instruments used for all procedures consisted of a 4.5-mm narrow dynamic compression plate and a 4.5-mm cortical screw. The humerus was approached using the standard anterolateral technique (Fig. 2A)[10]. The incision was made along the lateral border of the biceps with sufficient length to allow insertion of the plate. The space between the biceps and brachialis was identified, and the musculocutaneous nerve was visualized and protected. The biceps muscle was retracted medially, and the brachialis muscle was split longitudinally to expose the humerus. Half of the brachialis was used as a cushion to protect the radial nerve on the lateral side, and we avoided placing the Hohmann retractor on the lateral side to reduce the risk of radial nerve injury. The fracture was then reduced, and the plate was applied to the anteromedial surface of the humerus, achieving temporary fixation with a bone reduction clamp (Fig. 2B). The arm was externally rotated to facilitate the visualization of the anteromedial surface of the humerus and to insert cortical screws for fixation (Fig. 2C). The fractures were fixed using a compression plate in type A fractures. In contrast, the fractures were fixed with a bridging plate technique in type B and C fractures. Intraoperative fluoroscopy was used in cases of comminution where alignment and rotation were difficult to assess intraoperatively. The final steps included wound hemostasis, wound closure, and suction drain insertion. The surgery time, blood loss, and intraoperative complications were recorded. Plain anteroposterior (AP) and lateral humerus radiographs were obtained on the first postoperative day to analyze the quality of reduction (Fig. 2D).

Anterolateral Plating

We performed plate fixation through the anterolateral incision using the technique mentioned above; however, the plate fixation was applied to the anterolateral surface.

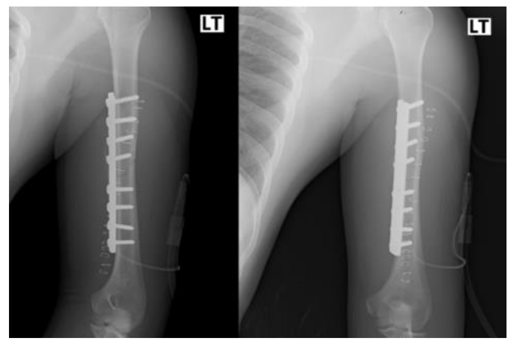
Postoperative Care and Follow-Up

A pouch arm sling was used, and the suction drain was removed 2 days postoperatively. The wound was inspected, and a sterile dressing was applied. A passive, assistive range of motion was encouraged from postoperative day 3 to avoid elbow and shoulder stiffness. Stitches were removed 2 weeks postoperatively.

A

B

C



D

Fig. 2 A: Skin incision. B: Exposure of the anteromedial surface of the humerus and application of the plate to the bone. C: External rotation of the arm and cortical screw fixation performance. D: Postoperative radiograph.

Patients were followed up at 2 weeks, 6 weeks, 3 months, and 6 months postoperatively and until radiographic union was achieved. Follow-up included plain radiographs and clinical assessments, such as pain at rest and the ability to perform activities of daily living. The following methods were used to assess plain radiographic parameters.

The patient was positioned for the X-ray by well-trained orthopedic residents. The plain radiographs included the shoulder and elbow. A high-quality AP view was indicated by the visibility of the medial and lateral epicondyles in the distal humerus and the greater tuberosity on the lateral aspect of the proximal humerus. For the lateral view, the medial and lateral epicondyles were superimposed, and the scapula was in a lateral (Y-shaped) position. The assessment was performed by one well-trained orthopedic resident and one trauma orthopedic surgeon without blinding, as the assessors could see the plate position on the plain radiographs. The radiographic parameters were recorded at the last follow-up or at the radiographic union, and the radiographic parameters are discussed below.

Union was characterized by the presence of bone bridging the fracture site across both cortices on radiographs taken in two planes, using established techniques for assessing tibial union, along with the clinical absence of pain and mobility at the fracture site[11]. Achievement of the union was acknowledged when the specified criteria were met within the initial 26 weeks, while the delayed union was characterized by union occurring after the 26 weeks[12].

AP angulation was measured on the AP view. The angle was measured by drawing a line along the axis of the humerus proximal to the fracture site and another line along the axis of the humerus distal to the fracture site. The angle between these lines represents the AP angulation.

Lateral angulation was measured similarly but along the lateral view of the fracture. One line was drawn along the axis of the humerus proximal to the fracture site, and another was drawn along the axis of the humerus distal to the fracture site. The angle between these lines represents the lateral angulation[13].

Sample Size and Statistical Analysis

The sample size, calculated using a test comparing two independent means in Stata version 15.1 (StataCorp LP, College Station, Texas), was determined based on a similar study. The primary outcome, the union rate at 3 months, was 97% for the study group[14] and 60% for the control group[15]. With a level of significance at 5% and power of 80%, the calculated sample size was 50. However, the total sample size became 60, allowing for a 20% loss to follow-up and dropout. Continuous variables, including age, time to union, operative times, blood loss, and alignment, were reported as mean and standard deviation or median and interquartile ranges. Categorical variables were presented as frequency and percentage. Differences in continuous data were assessed using Student's two-sample t-tests or the Wilcoxon rank sum test. Differences in categorical variables were evaluated through the chi-square test or Fisher exact test. A $p<0.05$ was considered statistically significant. The reliability of measurements between two assessors was reported using a two-way mixed model intraclass correlation coefficient (ICC). The reliability was good, with an ICC of 0.954 for AP angulation and 0.938 for lateral angulation.

RESULTS

This study enrolled 62 participants. Table 1 presents the demographic data for the two groups. Baseline characteristics, encompassing sex, age, smoking status, mechanism of injury, and fracture type, were comparable between both groups. The primary mechanism of injury in both groups was a traffic accident. The predominant fracture type was the AO Foundation/Orthopedic Trauma Association (AO/OTA) type B in the anteromedial plating group, and a mix of AO/OTA types A and B in the anterolateral plating group.

Three patients each were lost to follow-up in both groups due to financial problems. Thus, the analysis included 27 and 29 patients in the anteromedial and anterolateral plating groups, respecttively. The data on union rate at the 3-month follow-up, time to radiographic union, operative time, blood loss, alignment, and complications in both groups are presented in Table 2. The union rate at the 3-month follow-up was 88.89% in the anteromedial plating group and 86.21% in the anterolateral plating group, with no statistically significant difference (p=0.762). The mean time to union in the anteromedial plating group was 13.54 weeks, whereas it was 12.75 weeks in the anterolateral plating group, with no statistically significant difference (p=0.649). Operative time was quite similar in both groups; however, the amount of

Table 2 Intraoperative and postoperative outcomes in both groups.

	Anteromedial plating group (N=27)	Anterolateral plating group (N=29)	p-value
Union at 3 months, n (%)	24 (88.89)	25 (86.21)	0.762
Union time (week)	13.54 ± 4.52	12.75 ± 7.78	0.649
Operative time (min)	79.19 ± 5.12	81.00 ± 6.16	0.822
Blood loss (mL)	146.67 ± 21.03	193.6 ± 23.55	0.145
Alignment (º)			
AP angulation	1.83 ± 0.53	3.42 ± 0.53	0.04
Lateral angulation	4.21 ± 0.84	3.10 ± 0.49	0.252
Complications			
Nonunion, n (%)	0	2 (6.90)	0.164

bleeding was slightly higher in the anterolateral plating group, although this difference was not statistically significant (p=0.145). AP angulation was significantly better in the anteromedial plating group, with a mean difference of 1.59º (p=0.04). However, this had little effect on the clinical and functional outcomes of the patients, and the alignment was acceptable in both groups.

Both groups had no radial palsy. In the anterolateral plating group, two patients experienced nonunion and required reoperation (Fig. 3). They underwent re-fixation using anterolateral plating and received iliac bone graft insertion, resulting in an uneventful union of the fractures.

A B C D

Fig. 3 A: Postoperative radiograph after fixation with anterolateral plating. B: Follow-up at 6 months showed nonunion of the fracture and loosening of screws. C: Revised fixation with longer anterolateral plating and an iliac bone graft. D: Follow-up at 6 months showed union of the fracture.

DISCUSSION

The gold standard technique for humeral shaft fracture treatment involves open reduction and fixation with a plate and screws, a well-established procedure[4]. Securing a strong fixation with the plate and screws is imperative for the early initiation of postoperative functional exercises and the restoration of limb function.

The cross-sectional shape of the humerus from the shaft to the distal metaphysis is triangular. It has three aspects: the surface, anteromedial, anterolateral, and posterior, where we can apply plate fixation[16,17]. Currently, anterolateral plating is the most widely used; however, it has some drawbacks. The lateral aspect of the humerus is rough, leading to medial gapping during fixation. The plate often needs to be pre-contoured before placement. In contrast, the anteromedial surface is smoother, allowing the plate to be placed without pre-contouring.

For effective biomechanical considerations, it is recommended to position the plate on the tension side of the injury, allowing placement on the anterolateral or posterior areas of the bone[18]. In contrast to the femur or tibia, which primarily bear weight, the humerus experiences significant rotational forces, enabling placement of the plate on the medial aspect[19]. Some studies indicate that anteromedial plates exhibit mechanical properties similar to those of anterolateral and posterior plates, which implies that the fixation strength of anteromedial plates meets the mechanical requirements for humeral shaft fracture surgery[20].

Sanjay et al. performed medial plating through an anterolateral approach to stabilize humeral shaft fractures and found that the average operative time was 45 min, shorter compared to our study's 79 min; however, they reported an average blood loss of 200 mL, significantly more than our study's 147 mL. Callus was observed from 8 to 10 weeks. Within 3 months, patients had reintegrated their routine activities back into their lives[14].

Rai et al. conducted a prospective observational study to compare anteromedial and anterolateral surface plating through an anterolateral approach in mid-shaft humeral shaft fractures. They discovered that anteromedial surface plating decreased fracture exposure time (24 min vs. 47 min, p=0.05) and blood loss in dissection (50 mL vs. 110 mL, p=0.05) significantly. Almost all patients (98.6%) achieved union at 12 months[9].

The study by Kirin et al. demonstrated the advantages of anteromedial surface plating using an anterolateral approach over anterolateral surface plating in terms of reducing the incidence of iatrogenic radial nerve palsy and operative time. They observed no cases of iatrogenic radial nerve palsy when using anteromedial plating, whereas anterolateral plating resulted in 11.46% incidence. The mean operative time for anteromedial plating was significantly shorter compared to anterolateral plating (55.45 min vs. 74.61 min)[21].

Recently, two randomized controlled studies compared anteromedial and anterolateral surface plating using the anterolateral approach. The first study, conducted by Gangwar et al., examined functional outcomes and union rates at 12 weeks. They found that functional outcomes, according to Rodriguez Merchan criteria, were good to excellent in 86.9% of the anteromedial surface plating group and 82.6% of the anterolateral surface plating group, with no statistically significant difference. The union rate at 12 weeks was 78.3%, with a mean union time of 11.7 ± 1.5 weeks for the anteromedial surface plating group, and 56.5% with a mean union time of 12.3 ± 1.8 weeks for the anterolateral surface plating group, with no statistically signifycant difference. The anterolateral approach used in this study differed between the two groups: in the anterolateral surface plating group, the brachialis muscle was split longitudinally to the bone, whereas in the anteromedial plating group, the biceps muscle was retracted medially, and the brachialis muscle was elevated from its medial margin, along with the musculocutaneous nerve[22].

The second study, conducted by Shodipo et al., examined iatrogenic radial nerve injury between the two groups. They found that iatrogenic radial nerve injury occurred in 9.3% of the anterolateral surface plating group compared with 4.8% of the anteromedial surface plating group, with no statistically significant difference[23].

In our study, we demonstrated no signifycant inter-group differences in union rate at the 3-month follow-up, time to union, operative time, blood loss, or complications. There was no radial nerve palsy in either group because our surgical technique uses the lateral half of the brachialis as a cushion to protect the radial nerve and avoids placing the Hohmann retractor on the lateral side. The advantage of anteromedial plating lies in its smooth surface, which slightly aids in improving AP alignment, as indicated in our study. However, the alignments after fixation in both groups are deemed acceptable.

Anteromedial plating offers benefits such as a simpler application of the plate on the smooth medial surface compared to the irregular anterolateral surface of the humerus, eliminates the need for plate contouring and leads to improved AP alignment as shown in our study, results in no iatrogenic radial nerve palsy, and comparable outcome with anterolateral plating. However, when using anteromedial plating in comminuted fractures, some concerns should be considered. Before screw fixation, the arm needs to be externally rotated, which can cause rotational malalignment. Therefore, our recommendation is always to check rotation using fluoroscopy and assess the shoulder's range of motion after plate fixation.

The strength of our study is that it was a prospective randomized controlled trial comparing anteromedial and anterolateral surface plating regarding union rate, operative time, blood loss, alignment, and complications. Another strength is that the operations were performed by a single experienced trauma surgeon using the same approach and techniques. A limitation of our study is that we did not compare functional and clinical outcomes between the two groups. Further studies should include a larger population and compare functional and clinical outcomes between the groups.

CONCLUSIONS

This study offers valuable insights into the outcomes of anteromedial surface plating for humeral shaft fractures through an anterolateral approach, demonstrating acceptable union rates and overall satisfactory clinical results. This fixation technique can be employed safely and effectively for humeral shaft fractures.

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Outcomes of Perilunate Dislocation and Perilunate Fracture Dislocation After a Minimum 1-Year Follow-Up Following Open Reduction and Internal Fixation Via the Dorsal Approach: A Retrospective Study

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Purpose: This study aimed to review and evaluate the functional and radiographic outcomes of patients with perilunate injuries after a minimum 1-year follow-up following open reduction and internal fixation with or without ligament repair.

Methods: This retrospective study included patients with perilunate injuries who underwent open reduction and internal fixation with or without ligament repair at our hospital between 2013 and 2021 with a minimum 1-year follow-up.

Results: Of the 22 enrolled patients, 18 and 4 exhibited perilunate fracture dislocation and perilunate dislocation, respectively. The mean follow-up period was 15.3 (12–20) months. The mean age of the patients was 30.5 ± 10.2 years. Notably, 20 (90.9%) and 2 (9.1%) patients were males and females, respectively. The mean flexion/extension angles were 67.2°/76.2°. The mean ulnar deviation/radial deviation was 25.4°/13.8°, and the mean pronation/supination was 85.6°/88.3°. As secondary outcomes, the mean grip strength was 80% of the uninjured side, modified Mayo wrist score was 73.6 (1 excellent, 6 good, 11 fair, and 4 poor), and visual analog scale during the activities of daily living (ADL) was 0.59. For radiographic outcomes, the mean scapholunate angle (SL angle) was 50.4°, SL gap was 2.43 mm., and carpal height ratio was 0.50. Four and nine patients had an incongruent Gilula's line and arthrosis, respectively.

Conclusions: Satisfactory results can be achieved with open reduction and internal fixation using a dorsal approach. Although some patients had abnormal radiographic findings, the radiographic outcomes may not correlate with the functional outcomes.

Keywords: perilunate dislocation, perilunate fracture dislocation, modified Mayo wrist score, scapholunate angle, carpal height ratio

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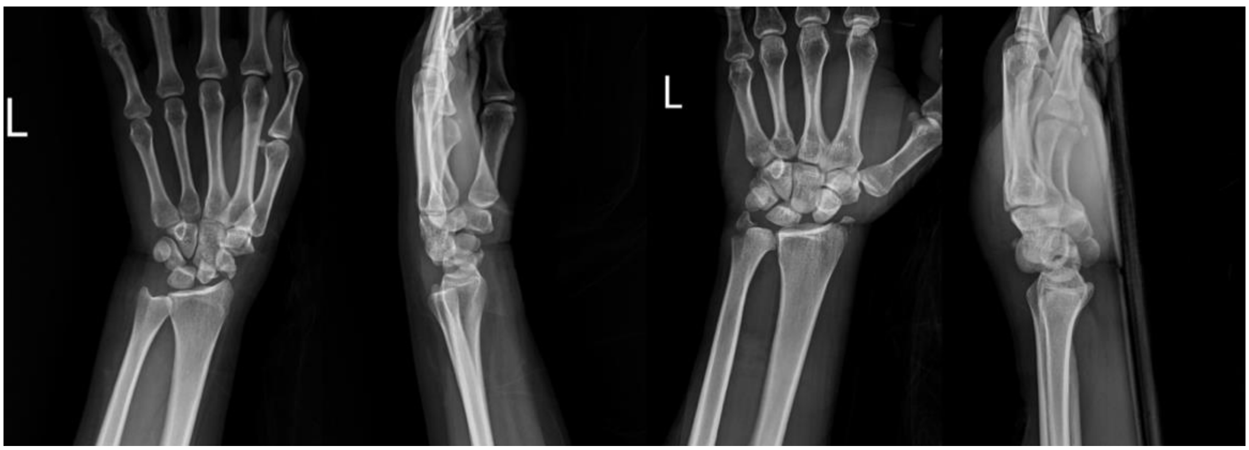
Perilunate injuries, encompassing perilunate dislocation (PLD) and perilunate fracture dislocation (PLFD) (Figure 1), are uncommon injuries[1,8] and usually occur in young patients due to severe injuries owing to traffic accidents, work-related injuries, or sports injuries[6,8]. The diagnosis of these injuries requires specialized expertise and supervision, and misdiagnosis may lead to delayed treatment and poor outcomes[14].

At present, open reduction is recommended to treat such injuries to re-align the bone and evaluate injuries to other structures, such as ligaments, cartilage, and carpus[2-8]. Open reduction offers the advantage of realigning the bone to its anatomical position and repairing of the ligaments. However, the techniques and outcomes of open reduction remain debatable[2-7,9-13]. In addition, complications such as joint stiffness and osteoarthritis of the wrist may arise from various treatments.

Therefore, this study aimed to evaluate the functional and radiographic outcomes of patients with perilunate injuries treated via open reduction and internal fixation using a dorsal approach.

Objective

To study the functional and radiographic outcomes of patients with PLD and PLFD after a minimum 1-year follow-up following dorsal approach surgery.



(A) (B) (C) (D)

Fig. 1 Radiographic images of a patient with trans-scaphoid perilunate fracture dislocation (A, B) and trans-radial and ulnar styloid perilunate fracture dislocation (C, D).

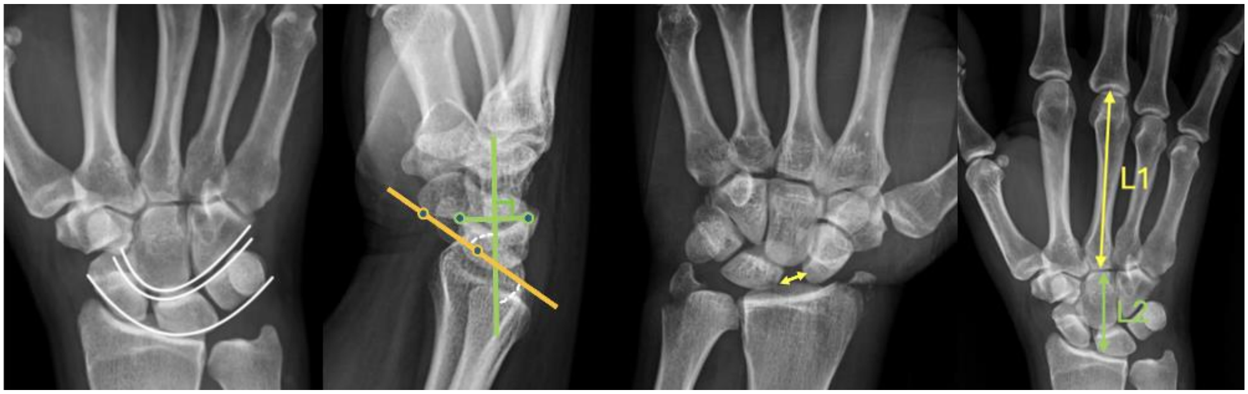
MATERIALS AND METHODS

Study Participants

Patients diagnosed with PLD and PLFD who underwent dorsal approach surgery from 2013 to 2021 and were followed up for at least 1 year were enrolled in this study. The inclusion criteria were as follows: (i) patients aged between 18 and 60 years and (ii) patients who underwent surgery within 6 weeks after the injury date. The exclusion criteria were as follows: (i) patients with injuries in the hand and wrist on the same side, affecting the movement of the hand and wrist and (ii) patients with multiple injuries, such as a brain or nerve injury, that affect hand and wrist movement. This study was approved by the Human Research Ethics Committee of our hospital (research project code: KEXP64085, dated December 7, 2021).

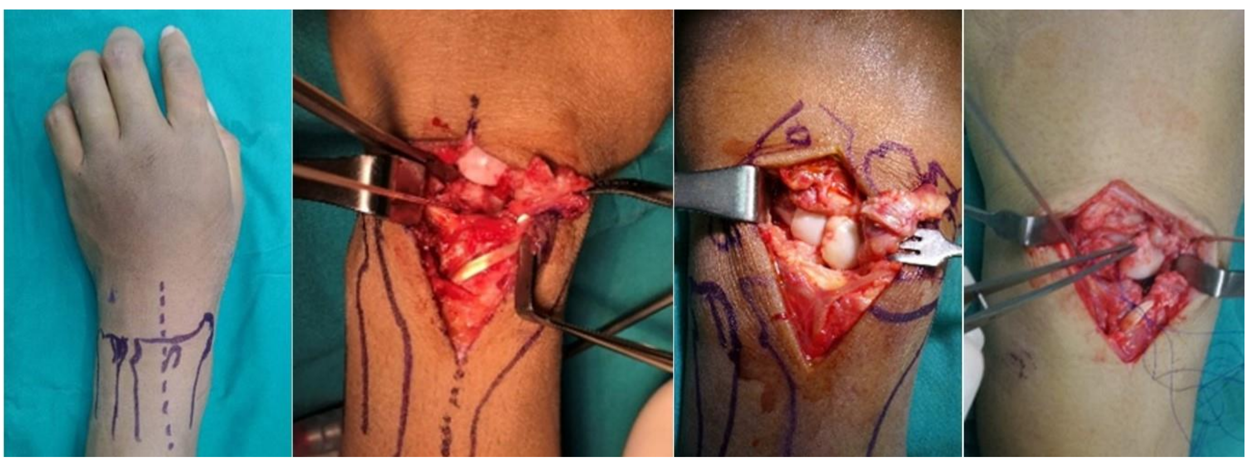
Methods

This retrospective study enrolled patients diagnosed with PLD and perilunate fracture dislocation who underwent open reduction and internal fixation via the dorsal approach from 2013–2021. Data were divided into the following two parts: (i) information from the medical records, including demographic data; information about the injury, diagnosis, follow-up period, and preoperative period; and functional outcomes such as range of motion, grip strength, modified Mayo wrist score, and visual analog scale. (ii) Information on the radiographic outcomes (Figure 2) of the injured carpal bones obtained from the infinite radiographic computer program of the PACS at our hospital. The following parameters were measured: scapholunate angle (SL angle), SL gap, Gilula's line, carpal height ratio, and joint arthrosis. Outcomes were measured after internal fixation and volar plaster slab removal (approximately 12 weeks), and the mean follow-up time was 15.3 months (12–20 months).



(A) (B) (C) (D)

Fig. 2 Trajectory of the Gilula's line (A), measurement of the SL angle (B), SL gap (C), and carpal height ratio (L2/L1) (D).



(A) (B) (C) (D)

Fig. 3 Surgical technique. Surgical incision on the wrist (A), 3rd extensor compartment was retracted (B), ligament splitting arthrotomy (C), transosseous suture for SL repair (D).

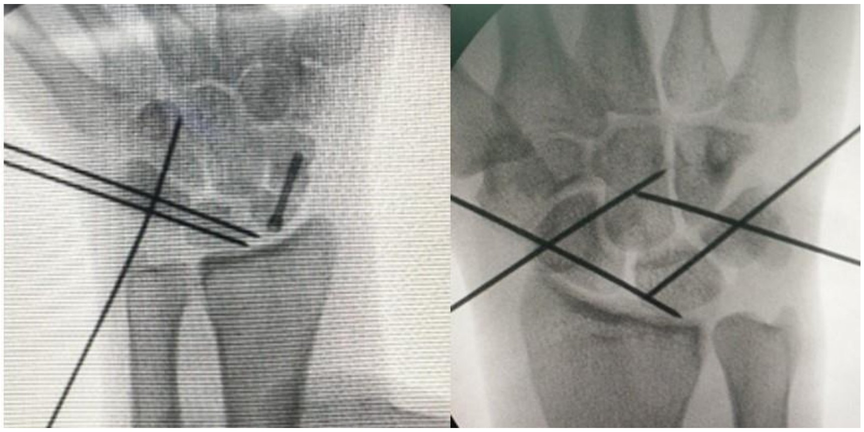
Surgical Technique

All patients who met the inclusion criteria underwent surgery under general or regional anesthesia. The surgery began with a dorsal longitudinal incision of the wrist (Figure 3A), and the extensor retinaculum between the 3rd and 4th extensor tendon compartments was opened (Figure 3B). The posterior joint capsule was exposed by retracting the extensor pollicis longus and extensor digitorum communis, including the extensor indicis proprius, laterally and medially, respectively. An arthrotomy was then performed using the ligament-splitting technique (Figure 3C) to access the injured carpal bones and ligaments.

In the non-fracture case, the patient was treated by repairing the ligaments between the lunate and scaphoid (SL ligament). Prior to suturing, the bone was aligned and fixed using a K-wire. The alignment of the bone and the K-wire was checked using a fluoroscope. A suture was then made through the bone to the SL ligament (transosseous suture) (Figure 3D). A transosseous suture technique was employed in cases where the ligament was avulsed from a bony origin. After repairing the SL ligament, the wound was closed by suturing the ligaments around the joint, extensor retinaculum, and skin using Nylon 3-0.

The surgical sequence in the case of fracture was the same as that in the case of non-fracture. When an open reduction was performed, the scaphoid bone was reduced and fixed using a headless compression screw (Figure 4A). For other fractured bones, the fixation was performed based on the location and size of the bone, usually using K-wires. (Figure 4A, 4B) The mid-carpal joint was also stabilized using K-wires. The overall carpal alignment was checked using a fluoroscope prior to wound closure.

Postoperatively, a volar plaster slab was applied for approximately 12 weeks. By week 8, the K-wire was removed, and the volar plaster slab was retained until 12 weeks. Following splint removal, physiotherapists and occupational therapists provided advice on physical therapy. Patients were recommended to continue physical therapy at home for at least 6 months.



(A) (B)

Fig. 4 Headless screw with K-wire fixation in trans-scaphoid perilunate fracture dislocation (A) and K-wire fixation in perilunate dislocation (B).

RESULTS

Of the screened patients, from 2013 to 2021, 40 were diagnosed with PLD and perilunate fracture dislocation (PLFD). Notably, 13 patients had insufficient data, and 5 did not meet the research inclusion criteria. Therefore, 22 patients, including 20 males and 2 females, were finally enrolled in this study. The mean age of the patients was 30.5 (18–55) years. Of the total patients, 16 (72.7%), 3 (13.6%), 2 (9.1%), and 1 (4.6%) exhibited PLFD, PLD, volar lunate fracture dislocation (VLFD), and volar lunate dislocation (VLD), respectively. For the surgical methods, the patients were divided into two groups as follows: (i) 10 (45.5%) patients underwent dorsal SL ligament repair with K-wire fixation, and (ii) 12 (54.5%) patients underwent headless screw fixation of the scaphoid or K-wire fixation of other bones. The mean follow-up period was 15.3 (12–20) months, and the mean period from injury to surgery was 9.5 (3–28) days.

The mean range of motion flexion/extension (SD) was 67.2° (10.1°)/70.1° (8.8°). Ulna deviation/radial deviation (SD) was 25.4° (4.3°)/13.8° (4.1°). The pronation/supination (SD) was 85.6° (3.8°)/88.3° (2.9°) (Table 1). The mean grip strength of the treated side compared with that of the normal side was 80% (8.6). The mean modified Mayo wrist score was 73.6 (7.3). The final modified

Mayo wrist scores were 4, poor; 11, fair; 6, good; and 1, excellent. The mean visual analog scale during ADL was 0.59 (0.66).

Radiographic Outcomes

The mean SL angle was 50.4° (10.1°). The mean of the SL gap was 2.43 mm (0.66 mm). The mean carpal height ratio was 0.50 (0.02). Notably, 18 (81.1%) and 4 (18.2%) patients exhibited congruent and incongruent Gilula's lines, respectively. In addition, 13 patients (59.1%) did not have joint arthrosis, whereas 9 had joint arthrosis, with 8 (36.3%) in mid-carpal and 1 (4.6%) in radiocarpal and mid-carpal (Table 2).

Table 1 Summary of Primary Outcomes.

Parameter	Wrist (n=22)	
	Mean	**SD**
Flexion/Extension (degrees)	67.2/76.2	10.1/8.8
Radial/Ulna deviation (degrees)	25.4/13.8	4.3/4.1
Pronation/Supination (degrees)	85.6 /88.3	3.8/2.9

Table 2 Summary of Secondary Outcomes.

Parameter	Mean	SD
Grip strength (% of contralateral hand)	80	8.6
Modified Mayo wrist score (point)	73.6	22
Visual analog scale at rest/ADL (point)	0/0.59	0/0.66
SL angle (degrees)	50.40	10.1
SL gap (mm.)	2.43	0.66
Carpal height ratio	0.50	0.02
Gilula's line: Congruence/Incongruence (%)	81.8 / 18.2	
Arthrosis: none/OA (%)	50.1 / 40.9	

DISCUSSION

Injuries around the lunate bones, non-fracture (PLD or VLD) and with fracture (PLFD or VLFD), are caused by severe trauma mechanisms, resulting in injury to the bones, ligaments, and surrounding soft tissues[1,8,14] and treatment complications such as joint stiffness and bone misalignment.

Surgery is currently the standard treatment for these injuries to align the bones (fractured and non-fractured) and suture ligaments. However, discrepancies exist in the surgical methods reported in the literature. Notably, dorsal, volar, and combined dorsal and volar approaches are applied to such injuries. However, reports on treatment outcomes are ambiguous. Dean et al.[10] reported that, compared with the normal wrist, the flexion/extension range of motion of the wrist and mean grip strength were 71% and 77%, respectively, in 11 patients with PLD and PLDF who underwent the combined approach, with 1 patient with osteoarthritis. Forli et al.[7] reported treatment outcomes for 18 patients, including 11 and 7 patients with PLD and PLFD, respectively, of whom 11, 3, and 4 were treated using dorsal, volar, and combined approaches, respectively, with at least 10 years of follow-up. Notably, the mean Mayo wrist score was 76 (60–90), with five, three, seven and three patients with excellent, good, fair, and poor results, respectively. Further, 12 patients were diagnosed with osteoarthritis, and the authors

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concluded that osteoarthritis could occur at long-term follow-up, but the patients tolerated such changes well. Kremer et al.(6) reported treatment outcomes in 39 patients, including 9 and 30 patients with PLD and PLFD, respectively, of whom 13, 6, and 20 were treated using dorsal, volar, and combined approaches, respectively, with a median follow-up period of 65.5 months. The mean flexion/extension arc was 77°, and the ulnar deviation/radial deviation was 42°. The mean visual analog scale at rest and during the activities were 1.8 and 4.8, respectively. Notably, 18 patients had a SL angle greater than the normal value, and 20 had osteoarthritis. Krief et al.(4) reported the treatment outcomes in 30 patients, including 14 and 16 with PLD and PLDF, respectively, of whom 2, 10, and 18 were treated using closed reduction with casting, closed reduction with percutaneous pinning, and dorsal and/or volar approaches, respectively, with at least 15 years of follow-up. Notably, the mean flexion/extension, radial–ulna abduction, and pronation–supination arcs were 68%, 67%, and 80%, respectively. The mean grip strength compared with the uninjured side was 70%. The mean Mayo wrist score was 70, and two patients with the lowest scores had osteoarthritis.

According to the severity of injury in patients with PLD and PLFD, which require surgical treatment, the combined dorsal and volar approach may cause additional soft tissue injury. Kevin et al.(11) reported flexion/extension arc and grip strength of 57% and 73% respectively, compared with the contralateral wrist, at an average follow-up period of 37 months in 22 patients (23 wrists) who underwent a combined approach. , three patients required wrist arthrodesis, four required an immediate scaphoid excision and 4-corner arthrodesis, and one required proximal row carpectomy. Consequently, a greater risk of complications exists after surgery using the combined approach than using a one-sided incision. The volar approach is used less commonly than the dorsal approach. Our study results for the primary outcomes demonstrated that the mean range of motion of flexion/extension, ulnar deviation/radial deviation, and pronation/supination were 67.2°/76.2°, 25.4°/13.8°, and 85.6°/88.3°, respectively. Notably, these values are close to those of Dean et al.(10), and they are greater than those of Kremer et al.(6) As the secondary outcomes, the mean grip strength, modified Mayo wrist score, and visual analog scale during ADL were 80%, 73.6, and 0.59, respectively. Our grip strength and modified Mayo wrist score results were comparable to those of other reports. The visual analog scale score in our study was better than that of Kremer et al.(6) However, our follow-up period was shorter, which precluded the comparison.

For radiographic outcomes, the mean SL angle, SL gap, and carpal height ratio were 50.4°, 2.43 mm, and 0.5, respectively. These values were close to normal values (SL angle 30–60°, SL gap ≤2 mm, carpal height ratio of 0.54 ± 0.03)(1). Four (18.2%) patients had a non-parallel Gilula's line, and nine (40.9%) had osteoarthritis, which was less than that reported by Forli et al.(7) and Kremer T et al.(6). However, the follow-up period in our study was shorter than others. Therefore, it may not be possible to definitively conclude that the dorsal approach decreases the occurrence of osteoarthritis.

Our study has a few limitations. First, this was a retrospective study, and some patients could not be included in the analysis because of insufficient data. Second, we did not separate patients with and without fractures in the data analysis, which may have influenced some of the data, such as the fixation of a headless screw for the scaphoid bone, resulting in bone shortening due to the compression effect.

CONCLUSIONS

The results of the surgical treatment for patients with PLD and PLFD using open reduction and internal fixation via the dorsal approach with a minimal 1-year follow-up were satisfactory. Although some patients develop osteoarthritis postoperatively, radiographic evidence did not correlate with the patients' clinical symptoms. Therefore, we recommend the dorsal approach as a well-accepted treatment option for patients with PLD or PLFD. However, further studies are warranted to compare the results of previous studies with respect to clinical and radiographic outcomes.

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Irreducible Fracture Dislocation of the Elbow Due to Medial Epicondyle Entrapment Associated with Median Nerve Palsy in Adult: A Case Report

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Purpose: Medial epicondyle fractures are common elbow injuries in pediatric and adolescent population. However, this condition is extremely rare in adults, with only a few cases reported in the literatures. This report presents the case of an adult patient with an irreducible fracture dislocation of the elbow due to intra-articular entrapment of the medial epicondyle associated with median nerve palsy.

Methods: A case of 36-year-old man presented with posterolateral fracture dislocation of the left elbow with displaced medial epicondyle and median nerve palsy. Closed reduction was attempted, resulting in a grossly unstable elbow. Post-reduction radiographic study demonstrated the articular incongruence with the entrapped medial epicondyle. The patient underwent an open reduction and median nerve exploration. A fragment of the medial epicondyle was found comminuted and repaired using our novel technique with suture anchors. The lateral ulnar collateral ligament was repaired because of varus residual instability. The dislocated elbow was successfully reduced.

Results: At 6 months follow-up, the elbow was stable with nearly full range of motion, although radiographic studies demonstrated union fractures with partially fragment resorption. Both sensation and motor function of the median nerve were gradually recovered.

Conclusions: We presented a novel fixation technique for a rare case of irreducible fracture dislocation of the elbow due to intra-articular entrapment of the medial epicondyle associated with median nerve palsy in adults. The median nerve should be explored in every case, and delayed diagnosis should be avoided, which may lead to devastating complications.

Keywords: irreducible elbow fracture dislocation, entrapment, incarcerated, medial epicondyle, median nerve palsy

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Medial epicondyle fractures are common elbow injuries in the pediatric and adolescent populations. Most injuries occurred in boys, commonly between the ages of 9 and 14 years. They account for up to 20% of all elbow fractures in pediatric patients and 60% of which are associated with elbow dislocation[1]. In addition, the entrapment of medial epicondyle may occur after closed

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reduction, which usually requires surgical intervention.

However, this phenomenon is rare in adults. There are only a few reported cases of entrapped medial epicondyles after closed reduction of the elbow in literature[2-4]. To the best of our knowledge, there has been no previous report of an incarcerated medial epicondyle associated with median nerve injury.

We present a case of irreducible fracture dislocation of the elbow due to intra-articular entrapment of the medial epicondyle associated with median nerve palsy.

CASE REPORT

A 36-year-old man presented with left elbow after slipping and falling from an outstretched hand. Physical examination in the emergency department revealed a swelling and deformity of the left elbow. There was a decrease in light-touch sensation in the area innervated by the median nerve, and paralysis of the flexor pollicis longus (FPL) and flexor digitorum profundus (FDP) of the index finger. The patient could perform palmar abduction of the thumb and fingers abduction and adduction without any weakness. Radiographic studies showed posterolateral fracture-dislocation of the elbow with a displaced medial epicondyle. A closed reduction was attempted under intravenous sedation, which resulted in a grossly unstable elbow. Post-reduction radiographic study demonstrated the articular incongruence with the entrapped medial epicondyle (Fig. 1). Computed tomography revealed comminution of the medial epicondyle fragment, a non-displaced radial head fracture, and avulsion of the lateral collateral ligament from the distal humerus (Fig. 2). To reduce the dislocated elbow, stabilize the fracture, and explore the median nerve, surgery was performed 4 days after the injury owing to limitations of the operating room.

After brachial plexus block, a curved incision was made along the medial aspect of the elbow. After carefully dissection, the flexor-pronator muscles were stripped from the medial ridge of the distal humerus, and the intact median nerve was identified with contusion along the nerve. Th ulnar nerve was identified proximally posterior to the intermuscular septum and released from the surrounding tissue along its course. The medial epicondyle was entrapped within the ulnohumeral joint, and the anterior bundle of medial collateral ligament (AMCL) was attached to the fragment. The fragment was meticulously removed from the joint.

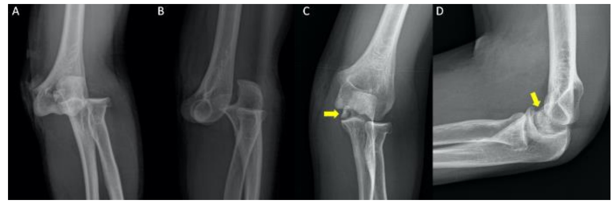

Fig. 1 Pre-reduction (A,B) and post-reduction (C,D) plain radiographs in AP and lateral views. Incarcerated comminuted medial epicondyle fragment is labelled with yellow arrows.

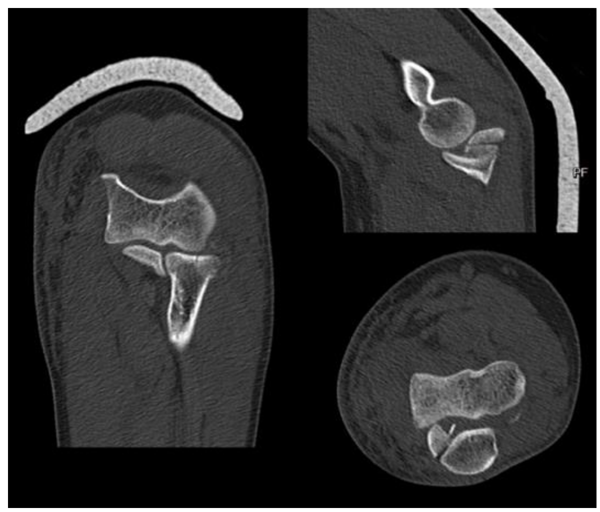

Fig. 2 Computed tomography of left elbow after closed reduction demonstrates incarcerated comminuted medial epicondyle fragment.

To stabilize the elbow, the medial epicondylar fragment with the attached AMCL was repaired. We applied a 3.5 mm metal suture anchor (PARCUS, USA) to the most distal fracture site of the distal humerus, passed the suture ends through the origin of the AMCL and grasped the collateral ligament using a Krackow stitch. The knot was secured after elbow was placed in flexion with varus force and the forearm was placed in the supinate position to achieve the proper tension of the AMCL. Because the medial condyle was comminuted, we decided to use suture anchor fixation instead of screw fixation to avoid further fracture. We applied another 3.5 mm metal suture anchor to the most proximal fracture site of the distal humerus, separated the two sutures to cover the anterior and posterior halves of the fragment, and tied the sutures with the other ends of the suture from the first suture anchor in a V-shaped configuration. Using this technique, we achieved a stable fixation of the comminuted medial epicondylar fragment (Fig. 3). The flexor-pronator muscles were repaired back to the humerus using vicryl 2-0. The ulnar nerve was left in place without transposition as it had no subluxation with elbow motion.

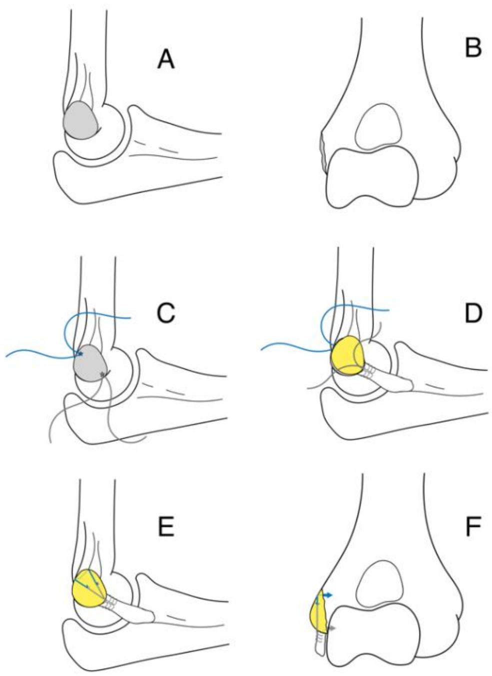

Fig. 3 Diagram of fixation technique. A and B = The fracture site of distal humerus (grey), lateral and AP views; C = Two anchor sutures are fixed to the most proximal and distal of the fracture site; D = The anterior bundle of the medial collateral ligament is grasped by the suture from the distal anchor using Krackow stitch, and both end are brought over the medial epicondyle fragment (yellow); E and F = Two sutures from proximal anchor are separated to cover the anterior and posterior halves of the fragment and tied over the fragment with the suture from the distal anchor, lateral and AP views.

After repairing all structures at the medial site, stability was evaluated using fluoroscopic assessment, and residual instability with varus force was confirmed. With another surgical approach on the lateral side of the elbow, the lateral ulnar collateral ligament was repaired back to its origin using a 2.5 mm metal suture anchor (PARCUS, USA). Both the surgical wounds were closed. The long-arm slab was placed in the neutral position. The elbow was immobilized in 90° flexion for 2 weeks to minimize swelling, and range of motion exercises were initiated.

Fig. 4 Postoperative radiographs of the left elbow 6 months after surgery.

Fig. 5 Range of motion of the elbow at 6 months after surgery.

At 6 months follow-up, radiographic studies revealed union fractures with partial fragment resorption (Fig. 4). However, the elbow was stable with a nearly full range of motion. Both the sensation and motor function of the median nerve partially recovered. The 2-point discrimination was 4 mm for the thumb, index, and middle fingers. The motor power of the FPL and FDP of the index finger was grade 4 on the Medical Research Council scale. The range of motion was 10-130° flexion with full rotation (Fig. 5).

DISCUSSION

In the pediatric population, medial epicondyle fracture is the most common fracture associated with elbow dislocation because it is the last ossification center that fuses in the distal humerus, typically between the age of 15-20 years[5]. In addition, the incidence of fragment incarcerated in the ulnohumeral joint after reduction is between 15% and 25% and the most common associated nerve injury is the ulnar nerve, given its location directly posterior to the medial epicondyle[1].

However, complex injuries are extremely rare in adults. There were only five reported cases of intra-articular entrapment of the medial epicondyle after reduction of the dislocated elbow of which only one case was associated with ulnar nerve injury[2-4]. Our presented case is believed to be the first reported case of incarcerated medial epicondyle associated with median nerve injury in an adult.

While the ulnar nerve is the most common nerve injury associated with elbow dislocation, the entrapment of the median nerve concomitant with elbow dislocation is a rare complication that commonly delays diagnosid[6,7]. In cases of median nerve palsy associated with elbow dislocation, we strongly recommend median nerve exploration to ensure no entrapment of the nerve.

The indications for surgical intervention for medial epicondylar fractures are inconclusive. Absolute indications included open fractures and fragments incarcerated in the joints. Several fixation techniques have been described, including Kirschner wire (K-wire) fixation, screw fixation, suture fixation, excision of the fragment, and repair of the soft tissue to the medial elbow[1]. Although there is no consensus for any technique over the others, K-wire fixation is mostly chosen in pediatric patients with small medial epicondyle fragments, while screw fixation is preferred in larger fragments[1,5,8,9]. However, in cases with comminuted medial epicondyle fragments, these techniques may not achieve stable fixation and might result in more comminuted fractures. In such situations, suture fixation can provide stable fixation without complication[10].

In our case, we presented a novel technique for fixation of the comminuted medial epicondyle and achieved good tension in AMCL repair using two suture anchors. Short-term follow-up confirmed a stable elbow with union of the medial epicondyle. The median nerve palsy was gradually recovered.

CONCLUSIONS

In conclusion, we presented a rare case of irreducible fracture-dislocation of the elbow due to intra-articular entrapment of the medial epicondyle associated with median nerve palsy in an adult. Our novel fixation technique using anchor sutures may be an alternative treatment method in patients with comminuted medial epicondylar fragments. Median nerve palsy after elbow dislocation is a devastating complication that should not be delayed and should be investigated in every cases.

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Pediatric Olecranon Fracture with Coronoid Process Osteochondral Flap Fracture: A Rare and Challenging Case

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Purpose: Osteochondral flap fracture is a variant of fracture in the pediatric age group. It is caused by a shearing force that separates the articular cartilage from the underlying subchondral bone. We present a pediatric case of an olecranon process fracture with an osteochondral flap fracture of the coronoid process.

Case report: A 10-year-old child presented with swelling and pain in the right elbow after an incident of direct trauma. A plain radiograph revealed multiple small fracture fragments, inconclusive of coronoid process involvement. Intraoperatively, we found an osteochondral fracture of the coronoid process with anteromedial facet displacement. The fracture was reduced and secured with two K-wires. The undisplaced olecranon fracture was fixed with a K-wire in situ.

Conclusions: Osteochondral flap fractures of the coronoid process can be easily missed and underestimated in imaging studies. Neglected fractures can lead to severe impairment of elbow motion and function and cause chronic pain. The anatomical reduction of the coronoid facet is crucial and yields the best outcome.

Keywords: Osteochondral flap fracture, coronoid osteochondral flap, pediatric coronoid process fracture

Pediatric osteochondral flap fractures are rare[1]. Unlike adults, children have thicker cartilage on bone surfaces, making radiographic findings less definitive and leading to diagnostic difficulties. A missed diagnosis can lead to limitations in the range of motion, elbow instability, and, eventually, osteoarthritis, affecting hand function and quality of life[2,3]. We report a case of pediatric coronoid process osteochondral flap fracture with a concomitant olecranon process fracture.

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CASE REPORT

A 10-year-old boy presented with right elbow pain and swelling after falling on a flexed elbow. He did not recall experiencing any dislocation or hearing popping sounds. Examination revealed non-specific tenderness and a limited range of motion due to pain. A plain radiograph showed an olecranon process fracture with bone chips of unknown origin at the medial and lateral aspects and a larger bone fragment at the anterior part of the elbow (Figure 1A). The provisional diagnosis was a closed fracture of the trochlea and olecranon process. A long arm posterior slab was applied, and he was admitted for surgery the following day.

Under general anesthesia, right elbow range of motion assessment revealed a restriction extension of 30–100° of maximum flexion. Preoperative examination showed a positive anterior drawer at 90° flexion. However, posterior subluxation and varus and valgus laxity could not be achieved. A tourniquet and sterile draping were applied. The arthrogram was inconclusive of the any trochlear or coronoid fracture. We percutaneously fixed the undisplaced olecranon process fracture with a 1.8-mm K-wire. A curvilinear incision was made at the medial elbow, slightly anterior to the medial epicondyle. A surgical plane was developed between the pronator teres and flexor carpi radialis to expose the anteromedial joint capsule. The capsule was opened, and joint washout was performed to remove the hematoma inside. We noted the fracture at the anteromedial facet of the coronoid process, along with its osteochondral fragment that was displaced anteriorly and superiorly (Figure 1B). We reduced the fracture and secured it with two 0.9-mm K-wires using the retrograde technique (Figure 2A). The trochlear, radial head, and capitulum articular surfaces and the medial collateral ligament were intact. The capsule was closed and the skin, sutured. A long arm posterior slab was applied. The diagnosis was revised to a closed fracture of the anteromedial facet of the coronoid process and a closed undisplaced fracture at the olecranon process of the right proximal ulna.

The child was discharged the next day with advice for pain-site dressing once every three days. At three weeks post-operation, the long arm slab and K-wires were removed, and elbow range of motion exercise was initiated. Six weeks after surgery, the child returned to school with nearly restored elbow motion, except for a slight residual extension lag of less than 10°. There was no laxity observed with the varus and valgus stress test. A radiograph showed the united fracture of coronoid and olecranon processes (Figure 2B). A six-month follow-up was given to monitor for any growth disturbances of the right elbow.

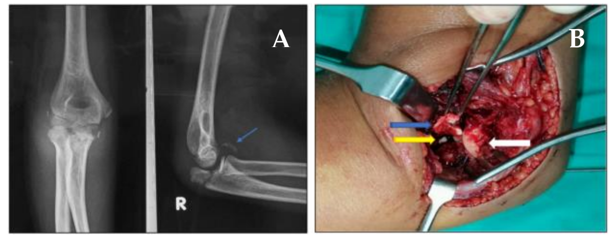

Fig. 1A Radiographs of right elbow. The blue arrow points to the osseous part of the displaced coronoid osteochondral flap fracture, which was initially thought to have originated from the humeral trochlear. **1B** Intraoperative image shows an anteromedial osteochondral flap fracture of the coronoid process (blue arrow) and intact lateral basal facet of the coronoid process (yellow arrow) and the trochlea (white arrow).

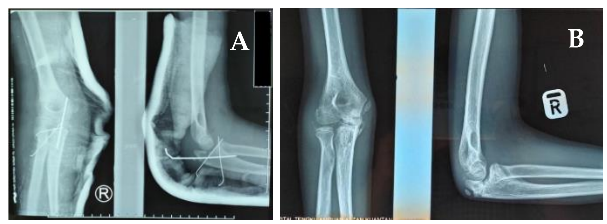

Fig. 2A Postoperative radiographs of the right elbow. **2B** Six-week follow-up radiographs.

DISCUSSION

Osteochondral flap fractures of the coronoid process in the pediatric age group are rare; to date, only a few cases have been reported[2-4]. Unlike adult hyaline cartilage, which comprises calcified and non-calcified layers, children's cartilage lacks calcification. Consequently, force is directly transmitted to the subchondral bone, causing osteochondral lesions instead of pure chondral injury, which is more common in adults[5]. Two injury mechanisms occur: first, during elbow dislocation reduction, the trochlea collides with the coronoid process, shearing off the osteochondral flap into the ulno-humeral joint. Second, falling with an outstretched hand and extended elbow causes the coronoid process to impinge on the trochlea, resulting in a fracture[2]. Osteochondral flap fractures can be classified into tip, anteromedial facet, and basal type fractures, further subdivided according to severity and associated fractures[6]. Posterolateral elbow dislocation involves a coronoid tip avulsion associated with a proximal radius fracture, while posteromedial dislocation is characterized by anteromedial facet fractures and collateral ligament complex injury(2). Anteromedial facet fractures are important because they are associated with posteromedial rotatory and varus instability, requiring vigilant and aggressive management(6). Reported injuries associated with a coronoid process osteochondral flap fracture include elbow dislocation, humeral lateral condyle fracture, ulnar collateral ligament injury, neck of radius fracture, and olecranon process fracture(1-4). Coronoid process osteochondral flap fracture with a concomitant olecranon process fracture has been described in younger children below 5–7 years of age, while our patient was 10 years old(2,4,7). We hypothesized that our patient presented after a spontaneously relocated elbow, similar to the case reported by Valisena et al.(2)

The diagnosis of coronoid process osteochondral flap fractures is a formidable challenge. Children have difficulty explaining the exact mechanism of their injury. Moreover, physical examination typically reveals nonspecific tenderness and limited range of motion due to pain from intra-articular fragment impingement. The small size and radiolucency of the fragment often lead to missed diagnosis on plain radiographs(1,3). A subtle increase in ulno-humeral joint space may be observed(4,6). Differential diagnoses include medial epicondyle, trochlear, olecranon, and radial head fractures. An early and accurate diagnosis is the cornerstone in treating osteochondral flap fractures. Therefore, due to the non-specific presentation and radiograph findings, we suggest proceeding further with computed tomography (CT) or magnetic resonance imaging (MRI) in suspected cases. CT helps in delineating fracture configuration but requires vigilant observation to detect the osteochondral fragment(1,2). MRI offers greater accuracy but is limited by its cost, availability, and the need for sedation in uncooperative children. Intraoperative arthrogram is another diagnostic option but may be challenging to interpret for inexperienced individuals. Open diagnostic exploration is the most specific method but is typically reserved for patients with additional injuries that require surgery.

It is pertinent to examine the integrity of collateral ligament complexes in all cases of coronoid fractures. However, stability assessment in children is difficult due to patient uncooperativeness and can, therefore, be performed under sedation or anesthesia. The medial ligamentous complex is assessed by applying valgus force with forearm supination at 30° of elbow flexion(8). Meanwhile, varus instability can occur in lateral ligament complex injuries with fracture of the coronoid, causing loss of the medial buttress. It is tested by applying varus stress with forearm pronation at about 30° of elbow flexion(9). Younger children have more laxity in their ligaments and yield a false positive unless compared to the normal side. Surgery is the mainstay of treatment for displaced osteochondral flap fractures as fracture reduction is crucial for the restoration of articular congruency and elbow stability. The medial approach to the coronoid process is advantageous as it allows direct access to the fracture site and medial ligamentous complex(4). The method of fixation varies among cases. Fragments larger than 5 mm should be fixed with K-wires, while smaller fragments can be fixed with absorbable sutures or fibrin glue(2,5). Elbow stability should be reassessed after fixation, possibly aided by observing joint space widening on the C-arm Image Intensifier. The passive range of motion in flexion–extension and supination–pronation should also be documented. In some cases, if stability is achieved post-reduction or the fragment is insignificant, fixation may not be necessary, and excision can be considered(2).

CONCLUSIONS

Coronoid process osteochondral flap fractures are challenging to diagnose and are often overlooked, especially when accompanied by other elbow fractures such as that of the olecranon process. Neglected fractures can result in the significant impairment of elbow function and in chronic pain. Imaging studies may underestimate the injury; therefore, careful clinical suspicion with surgical exploration is the most reliable diagnostic method. The assessment of elbow stability is necessary to identify any accompanying ligamentous injuries. Anatomical reduction of the coronoid facet is essential for optimal outcomes.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Osteochondroma at the Ventro-Medial Surface of the Scapula Causing Pseudo Winging Scapular Resection with Computer-Assisted Navigation: A Case Report and Literature Review

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Purpose: Osteochondromas, the most common benign bone tumors, primarily occur in the long bones, with scapular osteochondromas constituting less than 1% of cases. A unique challenge in ventral scapular osteochondromas is limited visibility from the dorsal side. Computer-assisted surgery, which is widely employed in tumor surgery is a promising solution for minimally invasive resection with reduced muscle injury.

Methods: We present the case of a thirteen-year-old female with a ventral scapular osteochondroma that cause winging and snaping of her left arm. The patient underwent computer-assisted surgery under general anesthesia in the prone position. The procedure involved a minimal incision over the crest of the scapular spine, enabling precise identification of the tumor from the dorsal side using navigation tools.

Results: The tumor, identified as an osteochondroma on CT scans, was successfully resected with minimal soft tissue damage. Postoperatively, the patient's arm was immobilized for two weeks, followed by a pain-free return to normal activity. Radiographic evaluation confirmed complete tumor removal.

Conclusions: Computer-assisted navigation can help locate the ventral osteochondroma of the scapula with minimal soft tissue damage and a quicker recovery time.

Keywords: osteochondroma, scapular tumor, computer navigated axis surgery

Osteochondromas are the most common benign bone tumors that are composed of medullary and cartilaginous bone covered by a cap of hyaline cartilage[1]. They are primarily found in long bones and increase in size with skeletal growth until skeletal maturity[2]. Scapular osteochondromas are rare, accounting for less than 1% of all osteochondromas[3-4]. However, they are the most common type of scapular tumors[5].

Currently, computer-assistance is widely used in tumor surgery, particularly for pelvic and sacral tumors. MIS resection of benign bone tumors is an indication for this technique[6]. In the past, several techniques have been used for resecting osteochondromas, including open resection with a triangle of auscultation approach[7] 3D models printed from DICOM files to help in surgery planning[8], minimally invasive techniques[9], and

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arthroscopic techniques[3]. However, the problem with ventral osteochondroma of the scapula is that it cannot be seen from the dorsal site. Therefore, we decided that computer-assisted surgery would be beneficial in this case to perform resection with minimal invasiveness and muscle injury.

CASE REPORT

A thirteen-year-old, right hand dominant girl presented to our orthopedic clinic with snapping on motion of her left arm for 9 months. Her left scapula had moved significantly anterolateral to the thoracic cage and slightly superior to the right side.

An anteroposterior view of the left shoulder joint with abnormal calcification at the medial border of the left scapula and a standard Y-view of the scapula clearly demonstrated that the tumor arose from the ventral aspect of the inferomedial border of the scapula.

CT reveled extension of the tumor over the ventral surface of the left scapula and lateral pushing of the left scapula, casing scapular winging.

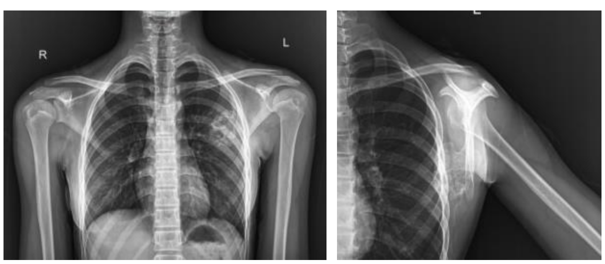

Fig. 1 Plain radiography anterioposterior view and standard Y-view of the scapula.

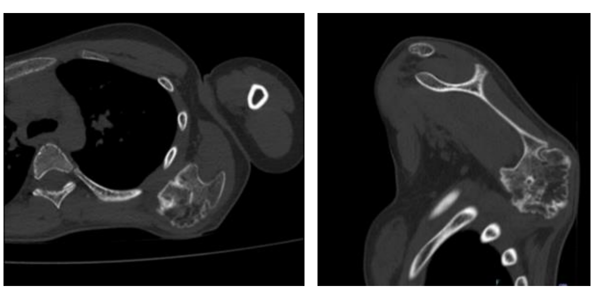

Fig. 2 CT scan showing osteochondroma arising from the left scapula.

The procedure was performed under general anesthesia, with the patient in the prone position. Her left shoulder was free and the scapula could move over the thoracic cage. A small incision was made over the crest of the scapula spine near the posterior part of the acromion. Five centimeters incision was made at the inferior pole of the scapula. We used 3-point acquisition at the medial border of the scapula and surface registration (Calibration using multiple points on the scapula).

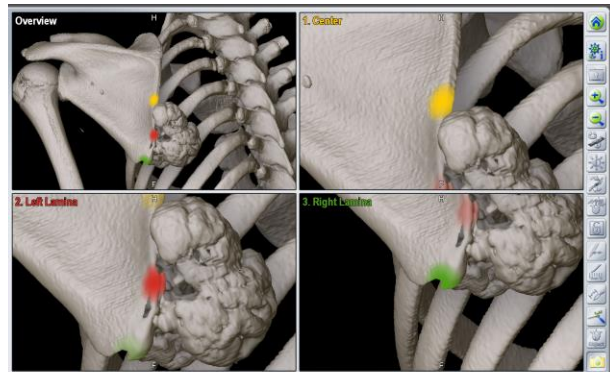

Fig. 3 Three-point registration at the medial border of the left scapula.

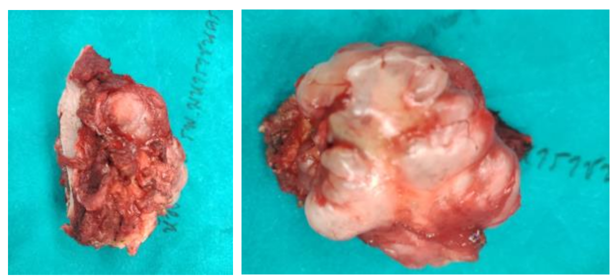

Fig. 4 Osteochondroma after resection.

After registration, a navigated probe can be used to identify tumors from the dorsal side. We used a Misonix Bone ScalPel blade to cut the bone and detach the inferior scapular and rhomboid muscles from the medial border of the tumor. After tumor removal, the muscle was reattached to the lower pole of the scapula, a drain was inserted, and the skin was closed. The resected tumor is shown in the Fig 4. The intraoperative duration spanned 1 h 30 min, with a blood loss of 50 mL.

Macroscopically, a pearly white hard mass extending from the scapula was observed, and the pathological report indicated that it was an osteochondroma.

Her arm was immobilized in an arm sling for 2 weeks, after which she could move her arm freely without pain. Plain radiography showed that the tumor was completely removed.

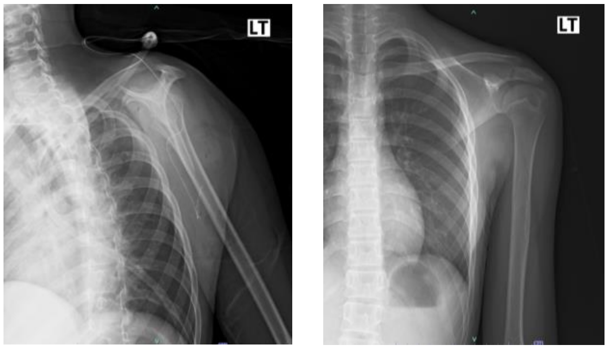

Fig. 5 Post-operative plain radiography showing complete resection.

DISCUSSION

Osteochondromas are the most common benign bone tumors, accounting for 15% of all bone tumors[5]. However, ventral osteochondromas of winging scapula are rare. A asymptomatic patients without pain or snaping can undergo non-operative treatment and follow-up measurements[10]. However, in the cases that lead to limitations in sports activities or impact the quality of life, surgical resection remains the treatment of choice.

In 2011, Pérez D et. al. used endoscopic guidance to resect a superomedial osteochondroma of the scapula. Minimally invasive resection of scapular osteochondromas has been proposed as an alternative to open surgery for early functional recovery[9]. In 2012, Tam MD et. al. used 3D printed model from a DICOM file for surgical planning in large scapular osteochondromas and tumor location during surgery[7]. In 2019, Sage et.al. reported case series of ventral scapular resected muscle spearing techniques with “triangular of auscultation” approach[11].

However, open resection from the medial or lateral border remained the standard approach in this case[12-20]. Ventral osteochondromas cannot be seen from the dorsal side and more associated muscles that attach to the scapula need to be resected, especially in large osteochondromas. Therefore, we propose a new technique that uses computer-assisted navigation to resect tumors. The scapula can glide over the rib cage, and the incision can be optimizied and resection can be performed with minimal muscle trauma. Although this may result in an increase in operative time, blood loss is slightly reduced. In this case, The patient returned to daily activities within 2 weeks of resection. Plain radiography and CT showed complete resection of the osteochondroma.

Computer-assistance is widely used in tumor surgery, particularly for pelvic and sacral tumors. This technique has the benefits of precise dissection, minimal damage to soft tissue, minimal invasiveness and a smaller incision, resulting in reduced post-operative pain, shorter hospital stays and less recovery time.

CONCLUSIONS

Here, we report the case of a 13-year-old girl with ventral scapular osteochondroma, highlighting the efficacy of computer-assisted navigation. This innovative technique allows complete tumor resection, minimizes soft tissue damage, and reduces recovery time. As technology continues to advance, tumor resection using computer-assisted navigation is likely to become the gold standard for surgical management.

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