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ORIGINAL ARTICLE • SHOULDER - FRACTURES

The dual subscapularis procedure: a modified Hawkins' technique for neglected posterior fracture/dislocation of the shoulder

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Abstract

Background Posterior fracture/dislocation of the shoulder is a rare injury that is frequently missed on initial assessment. It is frequently associated with reverse Hill–Sachs impression fracture. Several orthopaedics procedures have been described on the literature for reconstructable reverse Hill–Sachs lesion. The McLaughlin's procedure and its modifications, anatomic bone grafting procedures, rotational osteotomies, and the remplissage technique were reported by many authors. We advocated a new "dual subscapularis procedure" that consists of the Hawkins lesser tuberosity transfer with addition of filling the remainder of the defect with a part of subscapularis tendon.

Materials and methods In the period between January 2013 to December 2017, 12 patients (13 shoulders) suffering from a delayed managed posterior fracture dislocation were managed. Our inclusion criteria were adult patients less than 60 years presented with reverse Hill–Sachs impression defects from 20 to 50% with or without fractures. For all patients, the dual subscapularis procedure was done. UCLA score was used for postoperative functional assessment.

Results After a minimum follow-up of 6 months, the results of UCLA score were excellent/good in eight patients and fair/poor in five patients. All patients were found stable after open reduction ± internal fixation with no reported complications. There was a significant correlation of the UCLA score and non-abuse or lower doses of tramadol and the shorter interval between trauma and procedure. Twelve patients were satisfied after the operation.

Conclusion Reconstructing the reverse Hill–Sachs defect with the dual subscapularis technique provides adequate stability, pain relief, and function in patients with locked chronic posterior shoulder fracture/dislocation. The used technique has the merit of versatility with different fracture patterns, improved fixation of the tendon and increasing the tendon's footprint that ensures extra-articular location of the defect.

Level of evidence II.

Keywords Reverse Hill–Sachs · Posterior shoulder dislocation · Dual subscapularis procedure · McLaughlin's technique · Hawkins' technique · Tramadol

Introduction

Posterior fracture dislocation of the humeral head is a less frequent injury, usually associated with electric shocks, seizures, or high-impact injuries. Prompt diagnosis and adequate treatment are necessary to prevent avascular necrosis of the humeral head [1]. Despite being urgent, many cases are often missed.

Posterior shoulder dislocation accounts for only 1.5–4.3% of all dislocations. Associated fractures are even much more rare. In 50–80% of all cases, the dislocation is only recognized after initial assessment [2]. Anteroposterior radiographs of the shoulder are often not enough for accurate diagnosis of posterior dislocation of shoulder. Unless an axillary X-ray or a CT scan is done, posterior dislocation and/or fracture is often missed [3–6].

Malgaigne was the first to record this injury in 1804. Sir Ashley Cooper, in 1839, described the association with epileptic seizures. In 1937, Thomas confirmed the association

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with epileptic seizures, and he added electric caution as a cause of posterior humeral dislocation [7].

Nowadays, tramadol overdose is a common cause of seizures in our region. Tramadol is a centrally acting opioid analgesic for moderate and severe pain. Its analgesic potency is claimed to be about one tenth that of morphine. At supra-therapeutic doses and rarely at therapeutic doses, intoxications may occur and seizures are frequent [8]. Abuse of tramadol is reported in the Middle East and Africa for sexual and pain relief purposes. Because of increasing rate of abuse, Egypt has up-scheduled tramadol in 2009 [9].

On pathological basis, posterior dislocation of the shoulder comes in association with variety of injuries. These injuries vary from impaction fracture of the antero-medial aspect of the humeral head "reverse Hill–Sachs lesion" to more complex fractures of proximal humerus and shoulder girdle [4, 5]. Neer [10] classified these injuries as two-, three-, or four-part posterior fracture dislocations. More recently, a useful guide to the classification and treatment of the locked posterior dislocation of the shoulder is the size of the humeral impression fracture on CT image. It is classified into small defect (< 25% of articular cartilage), medium (25–50%), and large (> 50%) [6].

Different surgical procedures have been described for the treatment of medium-sized defects and unstable small defects. McLaughlin's procedure [11] involves detachment of the subscapularis tendon and reinsertion into the defect. Hawkins et al. [12] modified the technique by transfer of the fractured lesser tuberosity and its attached subscapularis muscle into the defect. Other modifications were utilized by using suture anchors and plication of the subscapularis tendon through open [13, 14] or arthroscopic procedures [15].

In the current study, we aimed to introduce the results of a new modification to Hawkins' procedure that involve the transfer of the lesser tuberosity to the reverse Hill–Sachs lesion, along with suture anchoring of a part of the subscapularis tendon into the remainder of the defect. We called this technique as "the dual subscapularis technique."

Patients and methods

The study was conducted as a single centre retrospective case series study. In the period between January 2013 to December 2017, 12 patients (13 shoulders) were enrolled. They were admitted to the hospital after a history of seizures (11 patients) and road traffic accidents (two patients). All cases were men, and the age ranged from 25 to 53 years. All were medically free except two patients with diabetes-related convulsions.

All of them were diagnosed as posterior shoulder dislocation or fracture dislocation after more than 3 weeks. Posterior dislocation was missed initially in 11 shoulders. The remaining two shoulders were diagnosed and managed initially, but were unstable with recurrent dislocation that treated several times by closed reduction. These two patients were referred to us due to failure of close reduction with locked posterior dislocations. Other causes of delayed presentation included multiple trauma patients who presented after neurosurgical interventions and patients' delay in seeking medical consultations after seizures.

Nine out of 12 (69.2%) cases were correlated with tramadol overuse for non-medical causes, and even in one case of road traffic accident, the seizure was thought to be the cause of the accident and then the fracture dislocation. In cases with positive history of non-medical tramadol intake, the average dose was (161.1 ± 60.1 mg/day), for average duration of intake (2.3 ± 1.1) years.

The primary assessment for them was done by routine X-rays (AP and axillary views) and CT scan. The percentage of Hill–Sachs lesions as calculated on axial CT, Neer's grade [10], and other patient demographics are shown in the patient characteristics Table 1.

Eligibility criteria

Inclusion criteria

- Adult patients less than 60 years suffering from either neglected posterior shoulder dislocation alone (two patients) or posterior fracture dislocation (nine patients).
- Reverse Hill–Sachs lesion with defect sizes 20–50% of humeral head in CT image (Fig. 1).
- Neglected cases with delayed or missed diagnosis after 3 weeks of the initial accident.
- Patient ability to provide a detailed consent.

Exclusion criteria

- Patients with glenoid bone loss or fracture.
- Previous shoulder joint infection.

Surgical technique

Under general anaesthesia, supine patient in a beach-chair position, the glenohumeral joint was accessed through a delto-pectoral anterior approach.

The long head of the biceps tendon was assessed, and both tuberosities were localized and released from the newly formed callus. The subscapularis muscle was detached carefully so as not to dissect or open the anteroinferior capsule, thus avoiding greater vascular damage. Visualization of the glenohumeral joint was possible after mobilization of the bone fragment(s) in a "trap-door" technique if needed. After meticulous removal of the scar tissue, the glenoid articular cartilage was examined and the humeral head was reduced

Table 1 Characteristics of the study group

Patients number	Age (years)	Duration before intervention (weeks)	Tramadol dose	Tramadol duration (years)	% reverse Hill–Sachs	Neer's grade	Follow-up time (months)
1	47	3	200	4	20	4	24
2	35	4	100	3	30	3	10
3	25	8	50	0.5	20	4	11
4	30	8	200	3	30	2	9
5	30	8	200	3	40	4	9
6	25	3	200	2	25	NA	24
7	53	4	200	1	30	4	8
8	47	3	200	2	20	2	10
9	35	4	100	3	20	3	6
10	40	9	No	NA	40	NA	10
11	28	7	No	NA	30	4	12
12	25	3	No	NA	25	4	18
13	53	4	200	1	20	4	12
Mean	36.4	5.2	165.0	2.3	26.9	NA	12.5
SD	10.5	2.4	58.0	1.1	8.9	NA	5.8

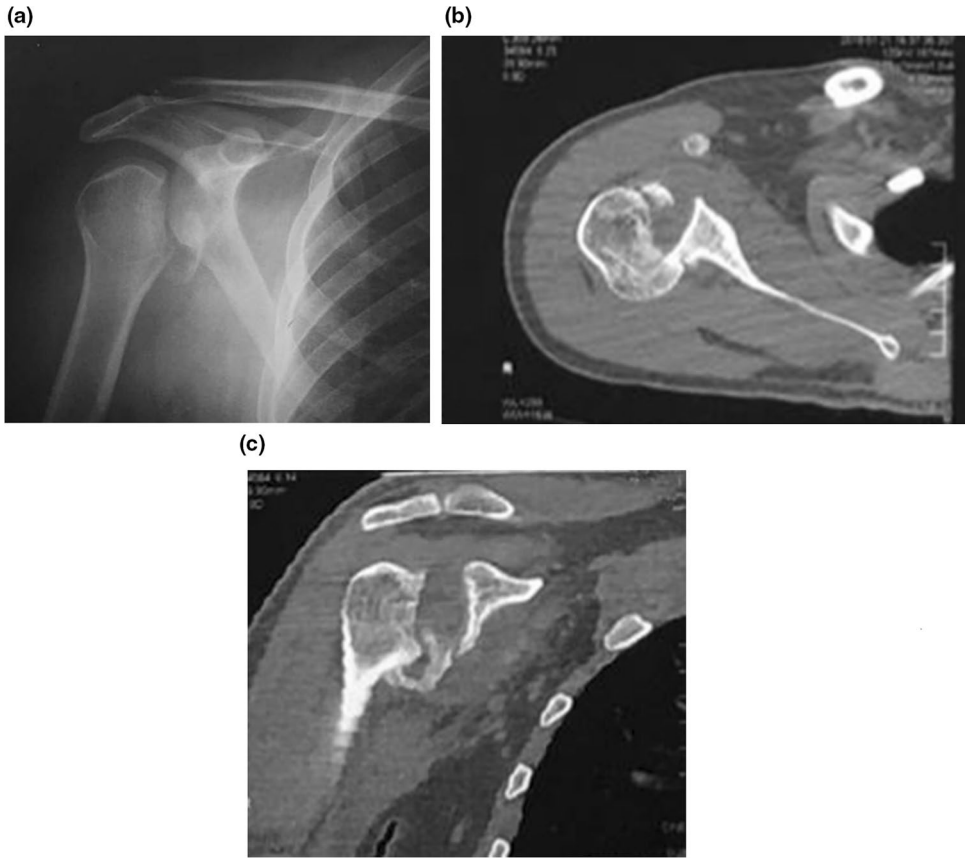

Fig. 1 **a** Plain AP view of the shoulder showing locked posterior shoulder dislocation, **b** axial CT image showing reverse Hill–Sachs of about 40%, and **c** another coronal CT cut of the same patient showing callus formation preoperatively

in combination with extra-articular pressure applied by the surgeon's hand. Then, the joint was assessed regarding stability with internal rotation movement.

1. In cases with reverse Hill–Sachs without proximal humerus fracture (two cases), (the dual subscapularis procedure):

First, the large reverse Hill–Sachs lesion was addressed and debrided with transfer of the osteotomized lesser tuberosity and its attached subscapularis muscle (Hawkins' procedure) to the antero-medial defect. Stable fixation of the lesser tuberosity was secured by a single partially threaded 6.5-mm screw. Second, further modification of the Hawkins' procedure is done by tendon-bone fixation of the subscapularis tendon by anchor (AR-1920SF Arthrex® corkscrew titanium anchor with two sutures size 5.5 mm × 15.5 mm each) to fill the remainder of the defect.

2. In cases of fracture dislocation (nine cases): (Fig. 2)

The greater tuberosity and anatomic neck fractures were stabilized in advance using plate and screws. Next to fracture stabilization, the lesser tuberosity was osteotomized (if not fractured) and the previously mentioned dual subscapularis procedure was done in the same manner as cases of reverse Hill–Sachs without proximal humeral fractures.

Postoperative care

Postoperative care included putting the shoulder in an immobilizer in external rotation for 4 weeks during which the immobilizer was removed for only passive external rotation exercises. Strict prevention of any internal rotation movements was advocated. Wrist and hand exercises were instructed to avoid their stiffness. At 4 weeks, passive shoulder and pendulum exercises were initiated and the patient was advised to use the sling for another 4 weeks. After 8 weeks, a progressive rehabilitation physiotherapy programme was initiated. It was comprised of active-assisted and progressive active range of motion and rotator cuff strengthening exercises. At 10 weeks postoperatively, full activity was allowed when plane X-rays showed maintenance of joint congruency, signs of bone healing, and signs of revascularization of the humeral head.

Patients were examined at 3 months and 6 months, and the University of California at Los Angeles (UCLA) scoring system [16, 17] was used in postoperative functional assessment. The parameters of UCLA score include subjective measures (pain, function, and patient satisfaction) and objective measures that include the range and strength of active forward flexion. Maximum score is 35, scores >27 are considered excellent/good, and scores <27 are considered fair/poor. In addition, we used to measure the range of internal rotation as a measure of morbidity to subscapularis muscle.

Radiographic assessment included plane shoulder radiographs (AP and axillary Velpeau views) and CT scan to confirm fracture healing, revascularization, and stability of the humeral head was obtained on each follow-up visit.

Data management

Data were collected using Microsoft Excel spreadsheet (Redmond, Washington) and analysed with SPSS v16 (SSPS Inc., Chicago, IL). Numerical data were expressed as mean and standard deviation. A P value of <0.05 was considered significant.

Results

After 6 months of follow-up, the active forward flexion was less than 150 degrees in seven patients (53.8%), while six patients (46.2%) were more than 150 degrees.

Eleven patients (84.6%) had limited internal rotation to the level of the sacroiliac joint, while two cases (15.4%) reached the upper lumbar spine. The external rotation was normal in ten cases (76.9%) and less than 45 degree in three cases only (23.1%); however, the overall range of movement was reduced in these three cases. A summary of the ROM at last follow-up is shown in Table 2.

The results of UCLA score (Table 3) were excellent/good in eight patients (61.5%) and fair/poor in five patients (38.5%). We found a significant correlation between the results of the UCLA score particularly in the results with the lower doses or cases without abuse of tramadol (P value $=0.034$). Also, we found a significant correlation between the results of the UCLA score particularly in the results of pain and the shorter duration before operative intervention (P value $=0.034$). Regarding patient satisfaction, 12 cases (92.3%) were satisfied with the results after 6 months and only one case (7.7%) was not satisfied with the results.

Regarding the incidence of midterm complications, we did not face any case of re-dislocation, instability, infection, hardware failure, or nerve palsies in our case series.

Discussion

Neglected posterior shoulder fracture dislocation represents a rare type of injury with low sample sizes reported in the past literature. Most of the articles published were in form of case reports [3, 18, 19]. There is a general consensus for arthroplasty in lesions with humeral defects larger than 50%. Also, in lesions less than 25%, grafting the defect is seldom necessary. Defects between 25 and 50% represent a challenge in management with no clear guidelines [6, 13].

The classic work by McLaughlin in 1952 remained the basis for the management for defects between 25 and 50% [11]. He was the first one who described the transfer of subscapularis tendon into the defect. 35 years later, Hawkins et al. described a modification of the technique depending

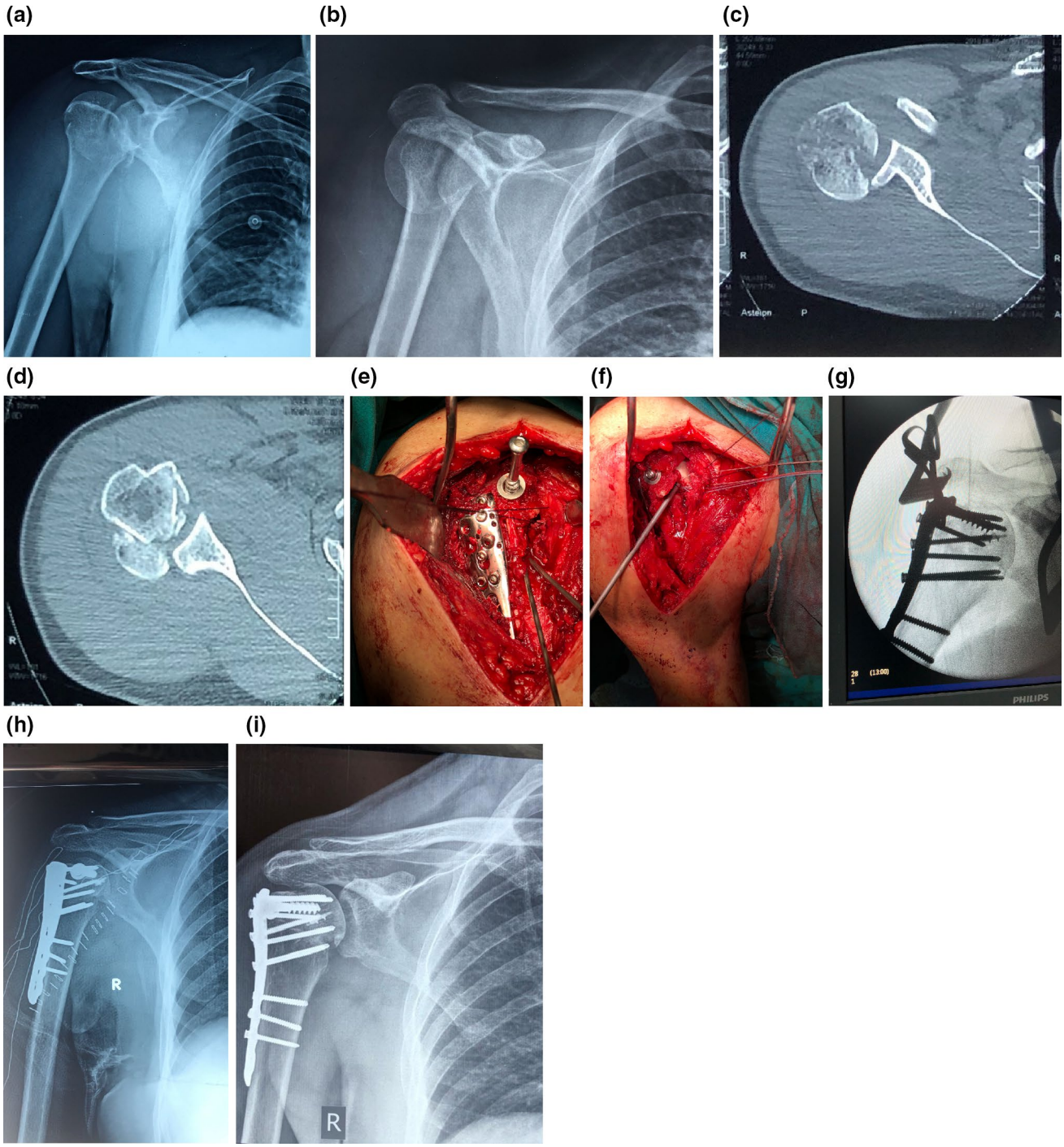

Fig. 2 **a**, **b** Plain AP and axillary views showing four-part fracture of proximal humerus presented to us 1 month after initial closed reduction in another facility, **c** reverse Hill–Sachs of 30% as shown on axial CT, **d** other axial CT cut showing the fracture parts, **e** intraoperative image showing the transferred lesser tuberosity after internal fixation by PHILOS plate, **f** intraoperative image showing the sutured tendon before filling the remainder of the defect, **g** C-arm image showing the internal fixation, the screw fixing the lesser tuberosity and the two anchors fixation of the subscapularis tendon, **h** immediate postoperative X-ray, **i** 6-month postoperative X-ray with healed fracture, no evidence of avascular necrosis

on the transfer of the detached lesser tuberosity into the defect. They emphasized the superiority of bone–bone healing over the tendon-bone healing in such situation. Charalambous et al. [14] in 2009 published a new modification that involved plication of the subscapularis tendon into the defect using suture anchors with the advantage of

Table 2 A summary of ROM at last follow-up

Patients number	Int rot 0–60 in add	Ext rot in add 0–80	Abduction 150
1	50	80	90
2	50	80	90
3	30	40	60
4	30	80	90
5	40	40	90
6	40	80	150
7	60	80	150
8	40	80	90
9	50	80	90
10	30	40	90
11	40	80	90
12	40	80	150
13	60	80	150
Mean	43.08	70.77	106.15
SD	10.32	17.54	31.50

secured tendon-bone fixation by anchors with the whole end of the tendon filling the defect. The whole Hill–Sachs defect is secured in extra-articular position. Shams et al. in [20] advocated usage of Ethibond sutures instead of the suture anchors in plication of the subscapularis tendon. Kokkalis et al. [21] in 2017 publish a comprehensive review about the posterior shoulder fracture dislocation. In their review, they reported good results that can be achieved by the subscapularis muscle filling procedures.

In our series, we advocated to use what we called "The dual subscapularis technique." We considered it as a modification of the Hawkins' technique that includes the addition of suture anchor fixation of a part of subscapularis tendon to the part of the defect that was not filled by the lesser tuberosity transfer. We hypothesized that the technique will carry many advantages. First, transfer of the lesser tuberosity depends on the stronger bone–bone healing and acts as a bone graft as in anatomic bone grafting procedure. Second, fixation of a part of the subscapularis tendon will fill the remainder part of the defect and will increase the footprint of the tendon. Third, fixation by anchor sutures is adding to the stability of the fixation that may allow earlier start of physical exercises. Fourth, complete filling of the Hill–Sachs defect will secure the extra-articular position of the defect.

The overall range of motion in our series was good and pain-free after 6 months postoperatively. The UCLA score was excellent/good in about 62% of cases with patient satisfaction in all cases except one. There were no reported cases of re-dislocation in our series. Our results are comparable to the results reported by most of the series discussing the different techniques of subscapularis filling procedures in terms of stability, range of motion, and function [21]. In addition, we claim that our result has the advantages of the more secure fixation that allows for early start of range of motion exercises and versatility to cover all fracture patterns except for comminuted lesser tuberosity cases that can be managed by suture anchors only [22].

Other surgical options were described by many authors who were in favour of anatomic reconstruction of the shape of the humeral head. Autogenous bone graft reconstruction of the defects using iliac bone graft and allografts was described by several authors [4, 23–25]. Jacquot in 2013

Table 3 UCLA score of the study group

Patients number	Pain	Flex 0–170	Strength of FF	Patient satisfaction	UCLA score results
1	10	100	4	Satisfied	31
2	10	170	5	Satisfied	33
3	2	45	3	Worse	8
4	2	90	4	Satisfied	18
5	2	90	4	Satisfied	20
6	2	170	5	Satisfied	33
7	2	170	4	Satisfied	28
8	2	120	4	Satisfied	31
9	2	170	5	Satisfied	33
10	2	100	4	Satisfied	19
11	2	120	4	Satisfied	17
12	2	160	5	Satisfied	33
13	2	170	4	Satisfied	28
Mean	3.2	128.8	4.2	Satisfied; *N* (%): 12 (92.3)	25.5
SD	3.0	42.1	0.6	Worse; *N* (%): 1 (7.7)	7.9

suggested balloon treatment like kyphoplasty that managed well in three patients [18]. We argue those types of surgeries by the donor site morbidity, lengthening the operative time in grafting techniques, and the technically demanding less reproducible procedure of ballooning. In Hawkins' procedure, the transferred lesser tuberosity fills the Hill–Sachs defect partially decreasing the need of bone graft to restore the remainder of the defect.

Further studies advocated rotational osteotomies after filling the defect with allograft [26, 27]. However, those techniques did not gain popularity with fear of avascular necrosis and advanced articular damage in addition to technical difficulties. Zafra et al. [19] in 2019 reported a case that was treated by a new type of osteotomy without rotation and they called it "subtraction osteotomy". However, their result cannot be generalized due to lack of case series. It is technically demanding as well. Magu et al. [28] in 2016 described a Check-Rein technique by transferring the coracoid process into the defect. We argue this technique as being a non-anatomic procedure making a subsequent arthroplasty a hard job. Few reports discussed the fixation of the subscapularis tendon into the Hill–Sachs defect arthroscopically [29–31]. However, those techniques need more speciality centres which may lead to further delay of management. In addition, it will not be suitable for cases of fracture dislocation necessitating open reduction. We argue that those techniques may be of value in stable reduced impression fractures only.

Regarding the incidence of complications in our series, we did not have a single case of infection, hardware failure, or instability. However, the range of internal rotation was limited to the level of sacroiliac joint in 11 shoulders (84.6%). This is not specific to our technique. It is considered as the main reported drawback of all the procedures sacrificing the subscapularis muscle. Long-term complications such as glenohumeral arthritis could not be appreciated in our series due to the relatively short follow-up period. Aparicio et al. [32] reported radiographic signs of glenohumeral arthritis in six out of seven cases in their series, and they related the degenerative changes to alteration of joint biomechanics after lesser tuberosity transfer in a non-anatomic position.

In our series, we found another correlation to non-medical use of tramadol in 69% of cases (nine out of 13). Abuse of its use is reported in our region as reported by WHO [8]. Among our patients, the average dose was (161.1 ± 60.1 mg/day), for average duration of intake (2.3 ± 1.1) years. It is still far below the maximum daily dose of 400 mg/day; however, seizures are reported even at therapeutic doses. There is risk of 54% of seizures in overdose and abuse. Tramadol abuse may be a cause of delay of diagnosis due to pain masking [9]. Associated injuries with tramadol abuse are cerebral oedema in 56%, cerebral concussion in 22%, cerebral haemorrhage in 5%, fractures in 17.8%, and polytrauma in 11%. Fawzi in 2010 labelled the tramadol abuse as "the new middle east youth plague" [9]. We have searched the literature for studies discussing the issue of posterior shoulder dislocation in our region, but we found only one study. Unfortunately, the tramadol abuse was not discussed in it [20]. This study may be of value as cases are expected to appear due to the widespread use of tramadol in certain community groups like manual labourers.

We found a significant relation between the results of the UCLA score and the shorter delay before operative intervention (P value $= 0.034$). Other authors [20, 33] noted similar results and emphasized the importance of the injury diagnosis time interval. They concluded that the joint mobility and the vascularity of the humeral head can be affected by missed fracture dislocation predisposing to chronic instability, osteonecrosis, and osteoarthritis. However, Lu et al. [34] concluded that when an appropriate surgical technique is utilized, satisfactory results can be expected with respect to different fracture types, and complications may be avoided regardless of delay.

Our study has a number of important limitations that must be considered. First, different patterns of fracture dislocation, or dislocation only included in this study due to rarity of this injury type, made it difficult in the statistical analysis of the result of the dual technique. Second, the follow-up period in this study was limited to the short-term functional and radiological outcomes. Third, the technique is not suitable for comminuted lesser tuberosity cases. Fourth, this study did not include a control group. Finally, the few number of recruited patients - the same situation in all articles highlighting the condition- is due to the rare incidence of cases.

Conclusion

The subscapularis filling defect techniques remain the gold standard of care in cases of posterior shoulder dislocation/fracture dislocations with medium-sized defects. Our proposed technique carries versatility in cases of dislocations and fracture/dislocation without affecting the outcome. The technique yielded good functional results and secured early reliable fixation that allowed early ROM exercises. No reported complications were seen. Tramadol abuse is a new factor that may increase the risk of this rare injury with more cases that are expected to appear in our region.

Recommendations

We recommend performing the dual subscapularis procedure after securing any accompanying proximal humeral fractures. Impacting the lesser tuberosity in the defect will help

to achieve partial anatomic restoration of the Hill–Sachs defect. Fixation of a part of the tendon into the defect will increase the footprint of the tendon, improve fixation, and secure the Hill–Sachs defect in extra-articular position. Also, we recommend multicentric studies or meta-analyses to include larger number of patients.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interests.

Ethical approval The study was approved by our local ethical committee and was in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent All patients signed an informed consent after clear explanation of the surgical procedure.

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