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Posterior shoulder fracture–dislocation: an update with treatment algorithm

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Abstract Posterior shoulder fracture–dislocation is a rare injury accounting for approximately 0.9 % of shoulder fracture–dislocations. Impression fractures of the articular surface of the humeral head, followed by humeral neck fractures and fractures of the lesser and grater tuberosity, are the more common associated fractures. Multiple mechanisms have been implicated in the etiology of this traumatic entity most commonly resulting from forced muscle contraction as in epileptic seizures, electric shock or electroconvulsive therapy, major trauma such as motor vehicle accidents or other injuries involving axial loading of the arm, in an adducted, flexed and internally rotated position. Despite its' scarce appearance in daily clinical practice, posterior shoulder dislocation is of significant diagnostic and therapeutic interest because of its predilection for age groups of high functional demands (35–55 years old), in addition to high incidence of missed initial diagnosis ranging up to 79 % in some studies. Several treatment options have also been proposed to address this type of injury, ranging from non-surgical methods to humeral head reconstruction procedures or arthroplasty with no clear consensus over definitive treatment guidelines, reflecting the complexity of this injury in addition to the limited evidence provided by the literature. To enhance the literature, this article aims to present the current concepts for the diagnosis, evaluation and treatment of the patients with posterior fracture–dislocation shoulder, and to present a treatment algorithm based on the literature review and our own experience.

Keywords Shoulder · Posterior fracture–dislocation · Reverse Hill–Sachs lesion · McLaughlin procedure

Introduction

Posterior shoulder dislocation (PSD) is considered to be a rare injury accounting for only 2–5 % of all shoulder dislocations [1]. Even less frequent, posterior fracture–dislocation represents 0.9 % of 1500 shoulder fracture–dislocations according to Neer and Foster, occurring annually in 0.6/100,000 people [2, 3]. In a 2012 systematic review by Rouleau et al., impression fractures of the articular surface of the humeral head, the so-called reverse Hill–Sachs lesion, were the most commonly associated fracture type (29 %) followed by humeral neck fractures (18.5 %) and fractures of the lesser (14.3 %) and grater (7.8 %) tuberosity, while other fractures (humeral diaphysis, scapula, clavicle) were present in 6 % of the cases [4].

Multiple mechanisms have been implicated in the etiology of this traumatic entity most commonly resulting from forced muscle contraction as in epileptic seizures, electric shock or electroconvulsive therapy [5]. Moreover, PSD may also follow major trauma such as motor vehicle accidents or other injuries involving axial loading of the arm, in an adducted, flexed and internally rotated position [5].

Despite its scarce appearance in daily clinical practice, posterior shoulder dislocation is of significant diagnostic

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and therapeutic interest because of its predilection for age groups of high functional demands (35–55 years old), in addition to high incidence of missed initial diagnosis ranging up to 79 % in some studies [6, 7]. Several treatment options have been proposed to address this type of injury, ranging from non-surgical methods to humeral head reconstruction procedures or arthroplasty with no clear consensus over definitive treatment guidelines, reflecting the complexity of this injury in addition to the limited evidence provided by the literature [1, 4, 5, 8]. Therefore, to enhance the literature, this article aims to present the current concepts for the diagnosis, evaluation and treatment of the patients with posterior fracture–dislocation shoulder, and to present a treatment algorithm based on the literature review and our own experience.

Definition and classification

Precise definition of the term "posterior shoulder fracture–dislocation" may not be as straightforward as one would expect. Putting aside the fact that in many cases it actually represents a subluxed humeral head locked in partial contact with the glenoid, confusion arises when attempting to interpret the term "fracture" [9]. By strict definition of the term, impression fractures of the articular surface of the humeral head should be included in the fracture–dislocation entity; however, several authors use this term only to refer to fracture lines of the anatomical/surgical neck and tuberosities [8, 9]. Addressing this inconsistency Robinson et al. introduced the terms "simple" and "complex" fracture–dislocation, in an attempt to further distinguish between a simple impression fracture and additional proximal humerus fracture lines, proposing a 3-type classification system for complex patterns using Neer's original classification for fracture–dislocations [3]. Many other classification systems have also been proposed over the years, taking into account the postdislocation position of the humeral head, duration of the dislocation and degree of residual instability, but none of them has actually emerged as the definitive instrument to approach this condition [1, 5, 10–13].

Nevertheless, chronicity has been identified as one of the key prognostic factors of this traumatic entity and decision over the acute or chronic nature of the condition remains mandatory in the process of treatment planning [1, 8, 9]. Though the exact duration of the dislocation in order to be classified as chronic remains controversial, with reported time periods ranging between 3 to 6 weeks, most authors agree that lately presented cases do not respond to conservative methods and are favored from operative treatment [6, 14–16].

Presentation and diagnosis

Posterior shoulder dislocation has been notoriously reported to evade diagnosis on first examination in about 60–79 % of the time, leading to significant morbidity including chronic pain, stiffness and functional disability [6, 14, 17, 18]. Moreover, a delay in diagnosis compromises vascularity and extends the head defect making final management trivial [18]. Schliemann et al. reviewed 35 patients with locked posterior shoulder dislocation treated either conservatively or operatively and found high correlation of the outcome with the time interval between injury and diagnosis [8]. The authors reported worse functional scores when this interval exceeded 4 weeks and suggested salvage procedures for delay periods over 3 months.

A careful history and clinical assessment, combined with a high index of suspicion, should lead to correct diagnosis, though in the presence of complex fracture–dislocations clinical signs may be less characteristic [19]. The patient will typically present with a prominent coracoid, posterior shoulder fullness and anterior flattening with a squared-off anterolateral acromion and overlying soft tissue, while holding his arm in adduction and internal rotation of between 10° to 60° [20]. Physical examination of the shoulder reveals marked limitations of both active and passive range of motion with respect to abduction and external rotation, while some patients may also demonstrate lack of forearm supination, signs often misinterpreted as a frozen shoulder condition [6, 21, 22].

A complete radiographic evaluation of the shoulder should include the trauma series (AP view, scapular lateral and axillary view) proposed by Neer [23]. Several signs have been described on the AP view to suggest a posterior shoulder dislocation. These include the evaluation of the "Moloney's line," extending from inferior glenoid rim to inferomedial aspect of the humeral head and neck, internal rotation of the humerus and "light-bulb" appearance of the humeral head, the "vacant glenoid sign" of the empty anterior glenoid fossa, the "rim sign" of over 6 mm margin between anterior glenoid rim and humeral head and the "trough line" of the impacted humeral head [24–26]. In daily practice though, these subtle indices may be missed by the untrained eye since the gross glenohumeral relations usually remain well preserved. Hence, the axillary and lateral scapular views are essential for diagnosis of PSD and may also help to estimate the size of the humeral head defect; thus, physicians should insist on obtaining them [27, 28]. Cicak comments that one of the main reasons for missing a PSD is that the axillary lateral radiograph is not taken [9].

Computed tomography (CT) is in an invaluable tool in the diagnosis, and overall evaluation of a posterior shoulder

dislocation and nowadays should be a routine examination for both suspected and confirmed cases prior to any closed reduction attempt [4, 17]. Especially in the setting of a fracture–dislocation, CT imaging will define the size of the humeral defect and amount of intact articular surface, as well as depict any additional fracture lines or fragments, allowing for a complete conceptualization of the pathologic anatomy of the injury to develop the optimum treatment strategy [1, 16, 29, 30].

On the other hand, MRI's role is limited in the acute setting of a fracture–dislocation since soft tissue injuries are quite rare and of secondary clinical importance. It can be useful in cases of pure dislocations that cannot be reduced by closed techniques or cases of residual instability and pain post-surgery [9, 31].

Relevant anatomy and biomechanics

A key point in the management of posterior shoulder fracture–dislocations is anatomy and biomechanics. The spheroid humeral head is centered within the relatively shallow glenoid fossa, representing only 25–30 % of the heads' articular surface, allowing wide range of motion at the expense of stability. The labrum, a fibrous structure circumferentially overlying the glenoid rim, increases the depth of the glenoid fossa by 50 % and acts as a static stabilizer of the glenohumeral joint along with the glenohumeral ligaments and joint capsule [32]. Dynamic stabilizers include the long head of the biceps tendon, rotator cuff tendons as well as the scapular rotator musculature and together with the static stabilizers create a double stabilization mechanism of glenoid concavity compression and scapulohumeral balance [5].

Cadaveric biomechanical studies have shown that a posteroinferior capsulolabral lesion of various extent is associated with a posteriorly dislocated shoulder in almost every case, predominantly at the point of attachment on the glenoid [33–35]. However, Schwartz et al. evaluated the role of posterior capsulolabral and ligamentous complex in joint stability and found that a complete posterior dislocation of the shoulder occurred only when the anterosuperior capsule, including the superior glenohumeral ligament, was deficient too [36].

Regarding stability, impaction lesions of the articular surface of the humeral head determine the stable arc of curvature of the glenohumeral articulation which decreases significantly in respect to their size. They have been graded as small, when they affect up to 25 % of the articular surface, medium, ranging between 25 and 50 % and large when over 50 % of the humeral head is impressed [9]. Reverse Hill–Sachs lesion is thought to be the single most responsible factor for posttraumatic recurrent posterior instability of the shoulder thus determining the treatment plan, as defects over 25 % demand operative intervention to restore stability [1, 5, 37]. Robinson et al. in their study of 26 patients with complex posterior fracture–dislocations treated operatively state that, when the head defect was restored intraoperative stability was achieved and addressing the posteroinferior capsulolabral avulsion was not required [3].

Treatment

Definitive treatment guidelines have yet to be produced regarding the management of posterior shoulder fracture–dislocation. Despite increased interest and ongoing research, the condition's rarity combined with a high percentage of missed initial diagnosis as well as pathoanatomical complicity, has been the main reason for the publication of relative low-evidence studies consisting of small case series or case reports. However, there seems to be a consensus on the key factors determining the optimum treatment plan. Duration of dislocation, patients' age and activity and the size of the humeral head defect are widely considered to serve a critical role in decision-making, along with the vascularity of the humeral head and degree of glenoid erosion [1, 8, 9, 15, 38].

Non-surgical

Non-surgical treatment is preferred in patients with limited functional demands (frail, demented, elderly), prolonged dislocations with minor functional disability and adequate range of motion, and also in patients suffering from unstable epilepsy [1, 15, 17, 39]. The goal of treatment in this group of patients is the establishment of a "functional" range of motion which will allow most of their daily activities despite symptoms of mild pain which can be present. This can be achieved through "supervised neglect" physiotherapy according to Gerber [40]. Especially for the elderly, this condition can be very well tolerated, and despite the deformity and loss of shoulder rotation, they usually report enough forward flexion to perform functions of daily living with minimal pain [37].

Closed reduction

Closed reduction under general anesthesia has been shown to produce good results when performed in acute cases, treated in less than 3 weeks after the injury, and combined with a humeral defect of less than 25 % [1, 17, 38, 41, 42]. Duralde et al. in their 2006 study reported excellent results for 4 out of 7 patients with defects up to 32 % (mean

27.6 %), treated acutely at about 2 weeks post-injury [41]. The author concluded that closed management can be highly successful even in the face of instability and a 30 % humeral head defect although all 7 patients had relevant comorbidities. Greater defects of the humeral head may be reducible, but the remaining instability in elevation and internal rotation can lead these patients to surgery sooner or later [18].

Although several closed reduction techniques have been proposed with satisfactory results, great care should be given to the correct selection of patients that will undergo this kind of treatment [43–45]. When the dislocation is present for a period longer than 3 weeks, the chances of achieving a closed reduction are reduced dramatically [16, 45].

As soon as a successful reduction has been achieved, the shoulder is usually immobilized for a 4-week period in a neutral or external rotation position, in order to prevent redislocation [8, 46, 47]. Patients should be encouraged to perform isometric external rotation strengthening within the brace. Temporary fixation of the joint with Kirschner wires for 6 weeks following the closed reduction has also been described but should be avoided for more than 8 weeks [17].

Complex posterior fracture–dislocations associated with non-displaced lesser tuberosity fragments or anatomical neck fractures can also be managed conservatively according to some authors [42, 45, 48]. However, closed reduction maneuvers may lead to propagation of the impression defect to an anatomical neck fracture or to the displacement of fracture lines already present in the surgical neck or tuberosities, increasing the risk for avascular necrosis of the humeral head [49]. Robinson proposes reduction only under direct vision to minimize the risk of further soft tissue injury or displacement of the humeral head [3].

Surgical

More severe injuries such as fracture dislocations with impressions over 25 % or additional fracture lines and missed cases for a period longer than 3 weeks require open reduction and some form of further surgical intervention to restore stability. Different treatment options have been proposed according to the size of humeral defect, duration of dislocation and patients' age, associated comorbidities and functional demands [9].

In the presence of complex fracture–dislocations, fragmentation of humeral head and tuberosities is another factor to be considered prior to operation (Fig. 1). Only a few case studies can be found in the literature dealing with this type of injury proposing mostly minimal invasive osteosynthesis techniques [47, 50–53]. Internal fixation increases the probability of osteonecrosis of the humeral head and non-union, but persistent dislocation of the humeral head and chronic lesser tuberosity fracture are worse predictors of the postoperative rate of avascular necrosis [52, 54, 55].

Open reduction

Open reduction should be performed in cases of a persistent dislocation over 3 to 6 weeks, humeral head defects of more than 20–25 % of the articular surface or concomitant fractures susceptible to iatrogenic displacement and in cases of unsuccessful closed reduction [1]. The surgical approach that will be used to perform the reduction has been a matter of controversy. A variety of approaches have been proposed in the literature, such as the deltopectoral, the posterior and superior deltoid-splitting approaches. The traditional deltopectoral approach provides excellent exposure to the anterior glenohumeral joint, but it does not provide direct visualization of the entire glenoid and humeral head [1]. If the surgeon prefers a better exposure of the glenoid and the humeral head, the posterior approach and the superior deltoid-splitting approach could provide good alternatives [56, 57].

Defect-filling procedures

The McLaughlin procedure has been one of the most common surgical techniques to address small to medium reverse Hill–Sachs lesions of up to 45 % of the humeral head. Through this procedure, first described by McLaughlin back in 1952, the subscapularis muscle tendon is transferred into the humeral head defect preventing engagement of the posterior glenoid rim in internal rotation thus restoring stability [58]. Walch et al. treated 10 patients with humeral defects of less than 50 % with this technique and reported 3 excellent, 1 good, 5 fair and 1 poor result [21].

Hughes and Neer later proposed a modification of McLaughlin technique by osteotomizing the lesser tuberosity and transferring it into the defect with the attached subscapularis tendon [59]. This modified McLaughlin procedure has gained popularity over the original technique as it is believed to offer a better bony filling and more secure reinsertion of the muscle and has produced good results in several studies [14, 15, 17, 60, 61]. However, Hawkins et al. published equally successful results for both groups of 4 patients each, treated with the McLaughlin and modified McLaughlin procedures [14].

In relation to chronicity, acute cases seem to correlate with superior outcome, while studies of neglected cases of

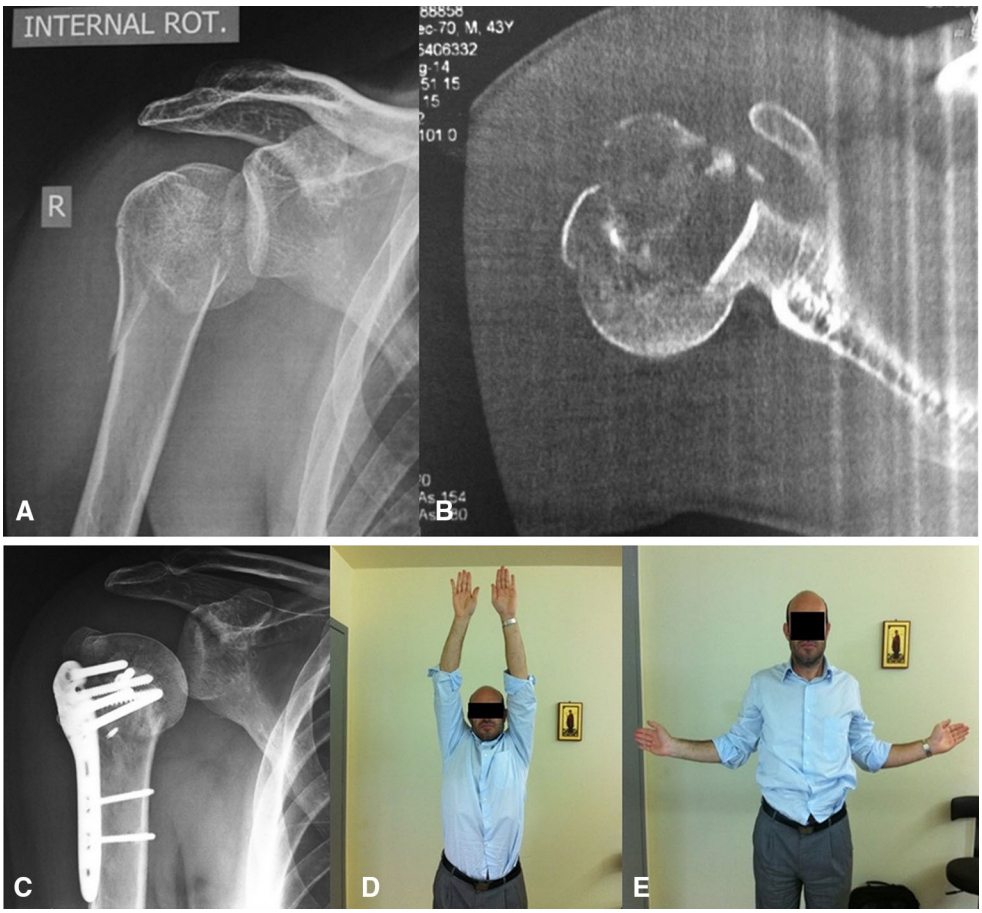

Fig. 1 **a** Anteroposterior radiograph and **b** axial CT scan of the right shoulder of a 43-year-old man show a 3-part complex posterior fracture–dislocation of the shoulder. **c** Anteroposterior radiograph of the right shoulder after open reduction and internal fixation. Photographs at 6-month follow-up show **d** flexion (175°), and **e** external rotation (90°); patient's satisfaction from the operation was excellent

up to 7 months produce inferior but comparable results nonetheless. Checchia et al. reported on a subgroup of 8 acute (<4 weeks) and 13 chronic cases of posterior shoulder dislocation associated with a head defect of 20–50 %, treated with lesser tuberosity transfer [60]. Four out of 5 reevaluated acute cases were classified as excellent, after a mean period of 35.6 months and one as good, while 9 reevaluated chronic cases were classified as: 3 excellent, 4 good, 1 fair and 1 poor result.

Castagna et al. reported on 16 patients, with defects ranging from 20 to 40 % of the humeral head in 13 cases and 50 % for the remaining 3, treated with lesser tuberosity transfer according to Hughes and Neer [17]. Mean period from trauma to surgery for this group of patients was 5.8 months (range 6 weeks to 7 months) and average follow-up was 5.23 years demonstrating a constant score (CS) increase from a mean 21.3 preoperatively to 75.2 post-op. However, two patients included in the study suffered from a concomitant fracture of the upper third of the humerus and were associated with worse outcome. Baneerje et al. in a recent study of 7 patients treated acutely with a modified McLaughlin technique within 14 days of a PSD with a 25–45 % humeral head lesion, reported 6 excellent and 1 good result after a mean follow-up of 41 months with a mean CS of 92 [61].

Other modifications of the original McLaughlin technique have also been proposed with good results. Spencer et al. proposed the incision of the subscapularis tendon in line with its fibers and use of anchors to suture as much of the muscle as needed to restore stability without detachment from the lesser tuberosity [38]. They reported satisfying results with no recurrent instability in 2 patients with defects less than 30 % and persistent dislocation of less than 8 weeks.

In previous studies, we introduced an alternation of the modified McLaughlin technique, treating 5 patients (6 shoulders) with chronic PSD and mean humeral defect of 38 % at an average time of 8 weeks after injury [62, 63]. In this study, we described the method of using absorbable suture anchors placed within the defect area to secure the

Fig. 2 **a** Anteroposterior radiograph and **b** axial CT scan of the right shoulder of a 45-year-old man show a posterior dislocation of the right shoulder and reverse Hill–Sachs lesion. **c** Anteroposterior radiograph of the right shoulder after a modified McLaughlin procedure using 2 suture anchors to secure the transferred lesser tuberosity. Three months postoperatively, the patent experienced complete return of function

osteotomized lesser tuberosity with the attached subscapularis tendon (Fig. 2). In addition, morselized fresh-frozen femoral head allograft was used to pack and elevate the defect, in an attempt to restore humeral head shape and induce healing. At a mean follow-up of 20 months, all patients were asymptomatic with stable shoulders and the reported average CS was 84 %.

However, these non-anatomical techniques have been criticized in the literature because they alter the humeral head anatomy and may limit internal rotation of the shoulder compromising an eventual secondary prosthetic reconstruction in the future [18, 60, 64–66]. Additionally, despite the fact that their results may be satisfactory, they remain significantly worse compared to techniques that anatomically reconstruct the glenohumeral joint especially in defects ranging from 30 to 50 % of the humeral head [54]. It was Dubousset who first suggested the use of autogenous iliac crest bone graft to re-establish the shape of the humeral head in combination with posterior capsule reconstruction [66]. Nevertheless, it was not until 30 years later that Gerber et al. published a series of 4 patients submitted to an allograft restoration of the humeral head without addressing posterior capsulolabral tear [64].

Good-quality subchondral bone matrix mostly encountered in young patients with dislocations of less than 12 months and no signs of osteoporosis, has been considered a prerequisite for allograft reconstruction [64]. However, according to a meta-analysis, decreased bone mineral density and frail skeleton in patients receiving antiepileptic agents do not significantly affect the allografts' efficacy [67].

Diklic et al. reviewed 13 patients with a mean age of 42 years, treated with a femoral head allograft reconstruction after sustaining a chronic PSD associated with a medium humeral head defect [54]. They measured the dimensions of the impression and prepared a wedge of the same size from the allograft with an oscillating saw fixing it into the defect with two or three partially threaded cancellous screws. For 2 cases in which the posterior capsulolabral complex had been avulsed, an additional repair procedure using bioabsorbable suture anchors was performed to induce stability. At a mean follow-up of 54 months, they reported an average CS of 86.8 and allograft incorporation in 12 patients with 1 developing spontaneous osteonecrosis of the humeral head.

In a recent long-term study, Gerber et al. reported excellent results for 19 shoulders at an average follow-up of 128 months postoperatively, including 4 cases from a previous preliminary study [64, 68]. Patients were of a mean 44 years of age and suffered from either acute or chronic (up to 15 moths) PSD with humeral head lesion of 43 % (range 30–55 %), with no relevant posterior glenoid rim fractures or avulsions. All patients were treated with segmental humeral head reconstruction, contouring the graft to fill the defect and restore the spherical shape of the humeral head. In five patients with defects smaller than 40 %, structural iliac crest autograft was used, while for the other 14 patients the authors used a segmental fresh-frozen femoral or humeral head allograft from an institutional bone bank. At final follow-up, mean relative CS was 84 % and 15 out of 19 patients indicated that they had no pain, whereas the clinical outcome in the 10 chronic cases was worse than that in the 9 acute and sub-acute cases (mean relative CS of 84 vs. 96 %). In respect to graft type, the authors commented that even though the allograft-treated cases were more chronic, and had larger defects and longer follow-up they did not produce worse results comparing to the autograft-treated patients, suggesting that restoration of the sphericity of the humeral head is the key factor for a favorable clinical outcome. None of the results were related to the age or gender of the patients.

Other authors have proposed elevating the depressed articular segment and filling the deficit with autologous graft or other material in order to restore head congruity much like treating a tibia plateau depression [69, 70]. Assom et al. reported excellent functional results for 2

patients with an acute lesion of 40–50 % supporting the chondral surface by the interference of a bioabsorbable screw [71]. Similarly, Re et al. used allograft cancellous bone chips to maintain the elevated segment in 4 patients, while Modi et al. filled the void with a moldable putty of tricalcium phosphate with carboxymethylcellulose in one chronic case, both reporting good to excellent results [72, 73]. In the largest case series, Bock et al. evaluated 5 patients with a reverse Hill–Sachs lesion of 30–45 % including 4 acute and 1 chronic case of a delayed diagnosis for 6 months [18]. They filled the void with spongiotic iliac crest bone, spongiotic allograft or a combination of both, while fixing the disimpacted cartilage on top using the absorbable suture material on the bone anchors introduced before under the affected area. The authors reported an average constant score of 88.2 points after a mean follow-up of 62.7 months with a redislocation episode 3 months after treatment for the chronic case who was managed with a second allograft head reconstruction combined with a dorsal capsulorrhaphy.

Rotational osteotomy

External rotational osteotomy of the proximal humerus ensures that the defect will not impinge on the posterior edge of the glenoid throughout the entire range of motion and has been proposed as an alternative to avoid arthroplasty in young patients with chronic defects of up to 40 % and a non-arthritic articular cartilage [74]. Keppler et al. reported good or excellent results for 6 out of 10 patients, with no incidence of redislocation or necrosis of the humeral head but with a residual mean external rotation of 7° [65]. Indeed, this technique has not been widely adopted, partly due to its technical difficulty and increased risk of devascularization of the humeral head and also due to significant restriction of external rotation up to 100 % for some cases as Surin et al. demonstrated [40, 75]. However, in a recent study of 4 patients treated for an acute posterior fracture–dislocation with a reverse Hill–Sachs lesion of 20–40 %, Ziran and Nourbakhsh report an average external rotation of 62° after a mean follow-up of 22 months [76]. These results probably reflect the great benefit of treating this condition acutely in addition to a younger population of average 40 years old in this series, compared to Keplers' chronic cases of average 53 years.

Arthroplasty

Shoulder arthroplasty, either hemi (HSA) or total (TSA), is usually used as a last resort to treat chronic dislocations over 6 months, associated with large defects over 45 % or deformities of the humeral head, in which all other options are estimated to fail [14, 60]. Gavriilidis et al. performed an additional surgery of latissimus dorsi transfer or rotator cuff reconstruction for 6 out of 10 hemiarthroplasties, concluding that arthroplasty is a technically demanding procedure and should be reserved for high-volume centers. He reported an average related constant score value of 67.1 after a mean follow-up of 37.4 months for 10 HSAs and 2 TSAs [77]. Hemiarthroplasties have been shown to produce inferior results regarding functional outcome and pain relief when compared to TSAs, while patient satisfaction in younger age groups has been significantly lower than in the elderly [14, 77–79]. In this light, deciding the optimal treatment for a young patient needing arthroplasty can be rather challenging. One could achieve better immediate functional outcome and pain relief choosing to perform a primary TSA but, in the long term, he would have to face a revision surgery in the setting of wear and loose implants in addition to glenoid erosion and low bone stock. In a recent study, Wooten et al. treated 18 patients with a HSA and 13 with a TSA for chronic posterior shoulder fracture–dislocation plus an over 45 % humeral head defect, using a glenoid component when one-third or more of the glenoids' articular surface was devoid of cartilage [80]. They followed the patients for a minimum of 2 years (average of 8.2), reporting thirteen unsatisfactory outcomes according to a Neer-modified rating system and concluded that the overall satisfaction rate is inferior to that of arthroplasty in the case of osteoarthritis.

Arthroscopy

Arthroscopic reduction and repair may be performed in cases of unsuccessful closed reduction when the humeral head involvement is of less than 20 %, healthy articular cartilage is present and loose bodies are found in the joint [81, 82]. It can offer the necessary support in achieving a closed reduction, preventing the morbidity related to open techniques, while allowing inspection of the entire glenohumeral joint [81]. However, arthroscopy in posterior shoulder dislocation has only been described in case reports and thus traditionally, when closed reduction fails open reduction is preferred [83, 84].

Arthroscopy could prove problematic in the context of complex posterior fracture–dislocations of the shoulder and ruptured joint capsule, due to the fact that visualization of the intra-articular space might be insufficient. Additionally massive periarticular swelling in prolonged arthroscopies may complicate future open surgical technique [85]. Nevertheless, Fukuda et al. in a recent publication reported the successful treatment of a type 3, according to Robinson, complex posterior fracture–dislocation, using arthroscopically assisted MIPO technique with excellent results [51].

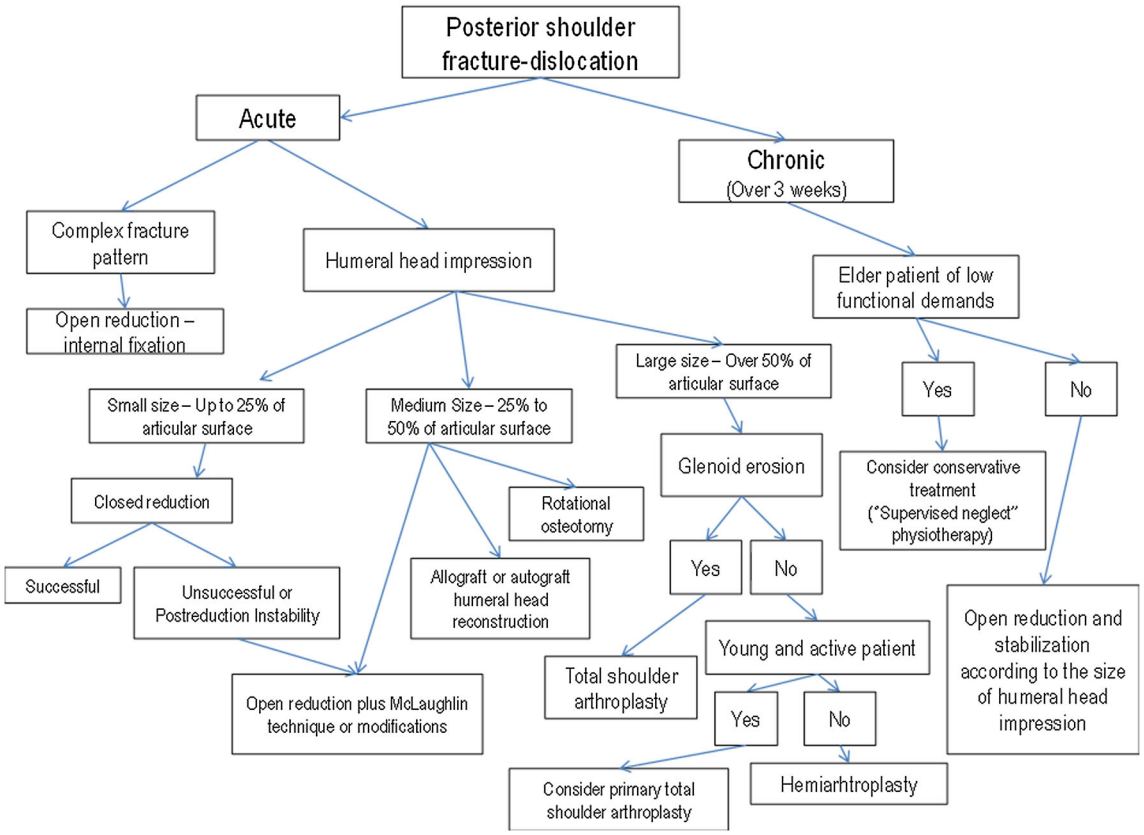

Fig. 3 Treatment algorithm for posterior shoulder fracture–dislocations

Conclusions

Posterior shoulder fracture–dislocation is a rare traumatic entity prone to be missed on initial presentation. Immediate diagnosis plays a critical role in the management of this condition as neglected cases demand operative treatment and are associated with inferior functional outcome. CT evaluation is mandatory to reveal and measure the possible reverse Hill–Sachs lesion, assess glenoid bone quality and conceptualize complex fracture patterns if present. Patients with acute (<3 weeks) dislocations and small humeral impressions can be treated conservatively if the shoulder is stable after closed reduction. Chronic cases or acute cases with defects over 25 % of the humeral head and complex fracture–dislocations demand open reduction and additional procedure to achieve stability. For medium impressions up to 50 %, modified McLaughlin techniques are recommended as they have been shown to provide pain relief and shoulder stability with good functional outcome. However, latest long-term results by Gerber suggest that anatomical humeral head reconstruction procedures can achieve at least equal results to lesser tuberosity transfer and perhaps even better for cases with defects over 35 %. In this light, segmental humeral head reconstruction could emerge as the treatment of choice for larger defects, especially in younger patients, in the years to come. In the context of severe lesions of more than 50 %, arthroplasty remains the preferred treatment, but for young and active individuals, decision between hemi and total shoulder arthroplasty should be reached after careful consideration and patient consent. Based on this review of the literature, a treatment algorithm for posterior shoulder fracture–dislocation can be proposed (Fig. 3).

Compliance with ethical standards

Conflict of interest All authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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