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**Biomechanics of posterior shoulder instability - current knowledge and literature review**

Bäcker HC *et al*. Current knowledge on posterior shoulder instability

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**Abstract**

Posterior instability of the shoulder is a rare condition and represents about 10% of shoulder instability. In the last year it has become more frequently recognized, even though it is more difficult to diagnose than anterior shoulder instability. As this form of shoulder pathology is somewhat rare, the biomechanical knowledge is limited. The purpose of our study was to perform an extensive literature search including PubMed and Medline and give an overview of the current knowledge on the biomechanics of posterior shoulder instability. The PubMed/Medline databases were utilized and all articles related to posterior shoulder instability and biomechanics were included to form a comprehensive compilation of current knowledge. A total of 93 articles were deemed relevant according to our inclusion and exclusion criteria. As expected with any newly acknowledged pathology, biomechanical studies on posterior shoulder instability remain limited in the literature. Current biomechanical models are performed in a static manner which limits their translation to explain a dynamic pathology. Newer models should incorporate the dynamic stabilization of the rotator cuff and the scapulothoracic joint. There is a current lack of knowledge with regards to the pathomechanism of posterior shoulder instability, no consensus on appropriate treatment regimens and further investigations are required both at the basic science and clinical level.

**Key words:** Anatomy; Shoulder complex; Scapula; Humerus; Glenohumeral; Posterior shoulder instability

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**Core tip**: Posterior shoulder instability is an infrequent type of injury and there is limited discussion within the literature. Other authors have acknowledged the current paucity of papers on this topic and to our knowledge no comparable literature review has been performed showing the interactions of the individual shoulder parts including osseous structures, capsule, labrum, ligaments and muscles[1]. This article aspires to help to develop new protocols to investigate shoulder instability and inform clinicians about the importance of this topic in daily practice.

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**INTRODUCTION**

The shoulder joint is the least congruent joint in the human body and thus has a tremendous potential range of motion with daily activities. These movements are a well-balanced and complex interplay between the osseous structures (scapula, humeral head and clavicle) and the surrounding soft tissue consisting of shoulder capsule, ligamentous, labral and muscular stabilizers. Dysfunction of one or more of these components through injury, degeneration or congenital abnormalities may lead to shoulder instability with the concomitant pain and dysfunction. Anterior laxity or dislocation occurs more commonly than the posterior equivalent and is thus more discussed in the literature: However, posterior instability is an equally important cause of patients’ pain and loss of shoulder function.

The first reported case of posterior shoulder instability was described by White *et al* in 1741[2], followed by a case study in 1839[3] and a clinical case series in 1855[4]. A variety of pathologies have been described regarding posterior shoulder instability, such as atraumatic lesions in ligamentous laxity, repetitive microtrauma (especially in overhead-throwing athletes or active duty military population) and traumatic posterior luxation[5,6]. In repetitive microtrauma the shearing force may cause a loss of chondrolabral containment - *e.g.,* frank labral tear[7,8].

Classifications for recurrent posterior subluxation have been established according its anatomical and biomechanical properties. It can be distinguished between volitional (ability to subluxate the shoulder using abnormal patterns of muscular activity), dysplastic (due to glenoid retroversion or humeral head retrotorsion) and acquired posterior shoulder dislocation (caused by soft tissue deficiency, bony deficiency or scapula-thoracic dysfunction) [5,9].

**LITERATURE SEARCH**

A comprehensive literature search was conducted using PubMed/ MEDLINE database (US National Library of Medicine, National institutes of Health) for shoulder instability and biomechanics/ anatomy of the shoulder between 1957 and 2017. The search terms were intentionally broad to maximize capture of the relevant literature. The following keywords were used “posterior shoulder instability” (*n* = 1026), “shoulder biomechanics” (*n* = 1389) and “posterior shoulder instability anatomy” (*n* = 295). Articles in English, German and French were included. All papers which evaluated the biomechanics on posterior shoulder instability as well as describing the anatomy in patients who suffered from posterior shoulder instability were included. Exclusion criteria included duplicate results, nonrelevant articles which did not involve posterior shoulder instability or biomechanical studies, and letters to the editors or comments. In total, 2710 abstracts were reviewed of which 128 articles were included according our inclusion criteria. These included papers describing the biomechanics of anterior shoulder instability (*n* = 16), the anatomy of the glenoid (*n* = 4), the glenohumeral capsular (*n* = 9), the ligaments (*n* = 7), the muscles (*n* = 5), the scapular (*n* = 23) and the vascular perfusion of the glenohumeral joint (*n* = 1). The remaining 68 publications described the clinical aspects (*n* = 49) and the anatomy/biomechanics of the posterior shoulder instability (*n* = 19). Because of redundancy another 40 articles were excluded, leaving us a total of 93 studies for the review.

**CLINICAL PRESENTATION OF POSTERIOR SHOUDLER INSTABILITY**

***Incidence***

The incidence of posterior shoulder instability is between 2%-5% of all shoulder dislocations[10]. According to the literature, it may be under- or mis-diagnosed due to lack of awareness and experience of treating physicians. 62.5% of patients who failed surgery and suffered from ongoing instability were diagnosed with unidirectional, posterior shoulder instability. Those patients demonstrated signs of inferior or multi-directional instability prior revision surgery which may be related to the capsular laxity. It seems to be underestimated – in 75% of these patients did not show labral tear, however would have required more aggressive stabilization[11].

***Current knowledge of biomechanics***

In the beginning of investigation, the mechanism was believed to be simply the counterpart to anterior shoulder instability[12-14]. Later on this paradigm was questioned by several researchers, who described the posterior shoulder instability as an unique injury condition [15-17].

Generally, posterior shoulder dislocation has been described in the setting of 90° forward elevation, adduction and internal rotation of the humerus[17-19]. Assumingly the humerus then dislocates either posterior through rupture of the posterior band of the inferior glenohumeral ligament (IGHL) or posterior inferior through rupture of whole posterior IGHL[20]. Unfortunately, the exact biomechanical mechanism of posterior shoulder instability is not well understood or described as of yet.

***Clinical presentation***

Posterior shoulder dislocation patients present with generalized symptoms about the shoulder and commonly include an intense discomfort with inability to mobilize the shoulder joint. This may be related to excessive stretch of the muscles or the joint capsule during the dislocation itself[21]. For clinical examination, the Kim test shows the highest sensitivity with 80% and specificity with 90%. Further examinations like the Jerk test, posterior apprehension test and stress test are useful to estimate the stability and dislocation tendency. The Jerk test is the most reliable diagnostic examination, however may only be pathologic in 4 of 50 patients suffering from posterior shoulder instability[22]. When performing the anterior apprehension test, patients may feel inconvenient with a slight anterior subluxation. However this test is neither sensitive nor specific[23]. The Kim test and Jerk test are illustrated in figure 1.

***Radiographic signs***

**X-ray and Computed tomography:** To exclude any osseous lesions and diagnose posterior shoulder dislocation, an anteroposterior, lateral and axillary radiograph should be performed. Furthermore, computed tomography (CT) may help to identify injuries of the shoulder complex such as reverse Bankart lesions or, when performing with intraarticular contrast, labral lesions. Displacement of the humeral head in relation to the glenoid, reverse Hill Sachs lesions or posterior Bankart/glenoid lesions may be pathognomonic for posterior shoulder instability but not necessarily present in all cases.

**Magnetic Resonance Imaging:** Magnetic resonance imaging (MRI) is an invaluable tool to assess soft tissue lesions about the shoulder. In patients who have suffered a posterior shoulder dislocation, a labral tear of the posterior wall or edema in the posterior humeral head is typically present. As well, other pathological conditions can be excluded such as superior labral anterior posterior lesions or rotator cuff tears masquerading as posterior instability (Figure 2 provided by Dr. Charles M. Jobin). When comparing conventional MRI with MR arthrography, MR arthrography is superior to assess glenohumeral pathology, Perthes lesions and labral tears[24].

The rigor of MRI and CT arthrograms in posterior shoulder instability is summarized in table 1.

**SHOULDER JOINT COMPLEX IN POSTERIOR SHOULDER DISLOCATION**

The glenohumeral, scapulothoracic, acromioclavicular and sternoclavicular joints can be summarized as the shoulder complex. A full range of motion including protraction/ retraction, elevation/ depression, anterior/ posterior tilt, internal/ external and upward/ downward rotation can only be achieved in combination of each individual joint[25]. The complex can be divided into osseous and soft tissue structures enabling stability and facilitating anatomic motion.

***Osseous***

**Scapula:** The scapula lies on ribs two through seven and is of triangular shape[26,27]. It is solely stabilized by soft tissue restraints through a series of bursal and muscular planes. Its position is obliquely in between the frontal and sagittal plane. Besides a slight abduction by 3°, it is located 30° to 45° anterior to the coronal plane with a slight anterior tilt between 9° to 20° in the sagittal plane in relation to the vertical line of the spine[25].

Multiaxial articulation can be enabled by the scapulothoracic joint between the humerus and the thorax. When elevating the humerus above 90° in the coronal plane, the scapular rotates mainly laterally in the coronal plane with less protraction in all 3 planes. At 30° and 40° of humeral elevation, a significant backward tilt occurs in the sagittal plane.

The glenoid cavity which forms the articular surface of the glenohumeral joint, is of concave in shape and slightly retroverted of 6.2°[28]. An abnormal glenoid shape such as higher retroversion or smaller cavity leads to a higher glenohumeral index, the relationship between humeral head and glenoid. This may predispose posterior shoulder instability[29-31] even though some authors could not reproduce this finding[32].

The most important osseous feature of the scapula is the coracoid process which is tilted approximately 120° to 160° anterolaterally[33]. It has several attachments which have major impact on the posterior instability: the coracobrachial muscle, the short head of the biceps brachii muscle, the pectoralis minor muscle, the coracohumeral ligament (although in a few cases they insert in the pectoralis minor muscle[34]), the coracoacromial ligament, as well as the coracoclavicular ligament. The individual function and mechanism of stabilization are discussed in full detail below.

The most frequent osseous lesion of the scapula involved during a posterior shoulder dislocation is the reverse Bankart lesion. It is located mainly in the posterior-inferior quarter of the glenoid (86%) and leads to an 86% increase in posterior translation and 31% increase in inferior translation of the humerus in the sulcus position. In patients with posterior capsular tears or posterior Bankart lesion, a bidirectional instability must be suspected[35].

In large glenoid defects, a posterior bone block transfer can be performed to extend the glenoid surface rather than reconstruct the glenoid anatomically. Additional indications for posterior bone block transfer include glenoid erosions, failure of primary capsular plication or congenital abnormalities. This procedure can be considered as the counterpart to the Latarjet procedure and was first described by Hindenach in 1947[36].

Overall, the posterior bone block transfer procedure shows poor results with a high rate of osteoarthritis in long-term follow up, although three of 11 patients were pleased with it[36].

In patients who suffer from higher glenoid retroversion (more than 15°-20°) with intact soft tissue, an open wedge osteotomy may be the treatment of choice. DeLong *et al*[37] performed a systematic literature review, stating that posterior glenoid osteotomy does not show any good results in terms of return to sport to pre-injury level as well[22,38].

**Humeral head:** The humeral head presents anatomically with a retroversion of 25° to 35° (related to the condyles of the elbow) and an inclination of about 130° related to the shaft[39,40]. It consists of hyaline cartilage – thickest in the center – and forms a true sphere[41,42]. Tendinous and ligamentous attachments form a ring to tighten and centralize the humeral head, placing it in the middle of the glenoid cavity[43,44]. Even though no data exist, it is likely that retroversion of more than 35° in humeral head may predispose posterior luxation, similar to retroversion of the glenoid.

**Glenohumeral joint:** The glenohumeral joint permits movement with many degrees of freedom including flexion-extension, abduction-adduction, circumduction and medial-lateral rotation. Humeral motion is possible in the frontal, coronal/ sagittal and scapular planes[25,45].

Damage of articular cartilage and reverse Hill Sachs lesions, also called Malgaigne fracture, are rather infrequent complications of posterior shoulder instability. In high traumatic injuries, Malgainge fractures may lead to painful clicking or catching in movements which may worsen the damage and lead to further injuries.

Surgical correction of a reverse Hill Sachs lesion includes the McLaughlin procedure where the subscapularis tendon is transferred into the bony defect. Other procedures include implantation of bone allograft or humeral osteotomy when the retroversion may be suspected to predispose the instability. Rotational osteotomies have shown fair results and one paper demonstrated a 50% return to pre-injury level of activity[46].

**Clavicle:** The clavicle is less important for posterior shoulder instability than the scapula. That being understood, the S-shape bone does provide some elasticity, some component of shock absorption and forms a strut holding the glenohumeral joint in parasagittal plane. At rest it is tilted slightly superior by 10° to 12°[25]. Major impact on the rotation in the coronal plane could be observed which increases from 3° at 20° to 21° at 150° of humeral elevation. Clavicle posterior rotation was increased by elevation in the sagittal plane between 20° at 90° to 27° at 150° of elevation as well as protraction from -17° to -45°[47].

The acromioclavicular joint is a synovial joint allowing anterior/posterior and internal/external rotation over the lateral end of the clavicle[48].

The sternoclavicular joint enables elevation and depression of the clavicle as well as protraction and retraction[48,49].

In an intact clavicle, the degree of freedoms are external rotation, upward rotation and posterior tilting – which are greatest in sagittal plane, enabling more stabilization and support in glenohumeral joint motion[50].

According to Poppen *et al*[45], the relation between the glenohumeral and scapulothoracic movement has a ratio from 4.3:1 with an upward translation of 3 mm. When abducting the humerus a counterclockwise rotation of the scapula in the frontal plane is accompanied. Hereby a rotation of the clavicle can be noted up to a taut costoclavicular ligament. After initial abduction by 30°, the glenohumeral and scapulothoracic joint movements occur simultaneously and facilitate elevation. Approximately 40° of abduction is enabled by the sternoclavicular joint and 20° by the acromioclavicular joint[25,51].

***Soft tissue***

With regards to the pathology of posterior shoulder instability, resistance to injury is provided substantially by the soft tissue. Most importantly are the subscapularis muscle, the coracohumeral ligament in neutral rotation, the coracohumeral ligament and the posterior band of the IGHL in internal rotation[20].

**Shoulder capsule:** It is believed that posterior instability is initiated by insufficiency of the capsule which secondarily leads to laxity of the joint. Various angles of humerus abduction have been investigated and emphasized the importance of the posterior capsule and the IGHL as significant stabilizers[52,53]. About 90% of patients show a rupture of the posterior capsule mainly on the scapular side after posterior shoulder dislocation. Ovesen *et al*[17,54] noted that between 40°-90° of abduction the major stability is conferred by the entire posterior capsule. When sectioning posterior structures such as teres minor, infraspinatus muscles and the proximal half of the posterior capsule, there was a significant increase in posterior displacement.

Tears of the lower and proximal half of the posterior capsule have only little impact on stability in internal rotation (mainly above 40° of abduction). An entire rupture of the posterior capsule increases displacement in the last part of abduction, however not significantly. In cases of posterior structure trauma, an increase in anterior instability can be seen as well[54].

Vice versa, lesions of the anterior capsule show even more impact on the posterior stability. The anterior capsule strengthens the glenohumeral ligaments by close adherence, superiorly the coracohumeral ligaments, posteriorly the teres minor and infraspinatus tendons and tightens in various positions. When sectioning the entire anterior capsule, posterior displacement significantly increases in abduction between 0 to 90°[17].

**Labrum:** The labrum is a circumferential soft tissue extension of the bony glenoid rim, which is loosely attached to the surrounding capsule. It allows compressing forces, called “concavity compression”, for stabilization and enables centralization of the humeral head[55]. In 52% to 66% a posterior labrum defect (also called posterior/reverse Bankart lesion) can be found after traumatic posterior shoulder dislocation[56]. No consensus exists on the association between posterior capsular laxity and reverse Bankart lesions[53,57].

**Ligaments:** There are several ligaments providing passive glenohumeral stabilization and help control the external forces on the glenohumeral articulation.

The coracohumeral ligament is divided into a superficial and a deep layer. The deep layer inserts into the rotator interval. It consists of fibers originating from the coracoid process and crisscrossing the supraspinatus and subscapularis muscles. These fibers form the pulley system that stabilizes the long head of the biceps at the entrance into the sulcus bicipitalis[57,58]. It allows external rotation and resists inferior and posterior translation in the suspended shoulder which enables resistance to posterior subluxation in neutral position[20,58].

Three main strands build the glenohumeral ligament: the superior, middle and IGHL. The influence of the IGHL on shoulder stability is well described. It is a thickening of the capsule with a prominent anterior band (between 2 to 4 o’clock)[59] and a less prominent posterior branch. Typically, the posterior band or the IGHL ruptures (posterior inferior part) in posterior dislocation (23 Blasier 1997) which can be provoked by elevation to 90° and abduction respectively internal rotation.

Today most stabilization procedures are performed arthroscopically and target the capsulolabral complex. Surgical techniques can be divided into those inclusive or exclusive of suture anchor capsulolabral repair.

Bradley *et al*[60] suggests using suture-anchor capsulolabral repair in completely or partially detached labral injury patterns. He stated a success rate with return to sport in 92% and 68% return to baseline when using suture anchors; otherwise, 84% and 48% respectively without suture anchors. The overall satisfaction is stated to be 94% measured with the American Shoulder and Elbow Surgeons Shoulder (ASES) score[60]. Savoie *et al*[53] published a study stating that the success was 97% based on Neer Foster rating scale in 92 patients after arthroscopically capsulolabral repair. The overall satisfaction in those patients who returned to sport at a pre-injury level was approximately 63.5% and the mean ASES score improved from 45.9 to 85.1[53,60]. Unfortunately arthroscopic methods are somewhat limited as the technique is not able to address severe erosions of glenoid bone or retroversion of the glenoid exceeding 15° to 20° nor volitional instability[30,61].

A rather infrequent method is the capsulorrhaphy, which shows good to excellent results in 73.3%; however 3 patients experienced a recurrent instability according to Bisson *et al*[62]. It should be noted in this study, surgical indications were very closely controlled as only patients with isolated posterior instability without labral detachment underwent this technique.

**Muscles:** There are 18 muscles with origins or insertions on the scapula and these can be classified according their function and location. Three main groups exist: Scapular stabilizers (*n* = 6), Rotator cuff (*n* = 4) and Scapulohumeral muscles (*n* = 6). The omohyoid muscle is not included in this simple classification as it originates from the superior border of the scapula yet it functionally depresses the larynx and hyoid. All tendons of the rotator cuff interact intricately with the fibrous capsule, which allows dynamic stabilization and movement of the glenohumeral joint. This group includes the infraspinatus, subscapularis, supraspinatus and teres minor. After posterior shoulder dislocation a rupture of the teres minor and infraspinatus tendon is present in most of the cases (90% partial, 10% total rupture)[25].

Biomechanical investigations demonstrate after teres minor tenotomy an increase of internal rotation by 7° at 30° to 40° of humeral abduction compared to an intact glenohumeral joint. Similarly, infraspinatus tenotomies show a significant increase in internal rotation between 0° and 30°/ 50° of abduction [32,54,63].

The scapular stabilizers include the levator scapulae which elevates and rotates the scapula, the pectoralis minor which protracts, rotates downwards and depress the scapula, the major and minor rhomboid muscles which retracts and elevates the scapula to depress the glenoid cavity, serratus anterior which performs protraction and upward scapular rotation and the trapezius muscle which is a passive and dynamic scapular stabilizer, active elevator of the lateral scapular angle, scapular retractor and rotator. The pectoralis major - which does not attach the scapula - potentiates the scapulothoracic stabilization of latissimus dorsi and deltoid muscle. This leads to a space of the scapulothoracic articulation between the surface of the posterior thoracic cage and the subscapular fossa[25,58] facilitating gliding movement.

The last group includes the scapulohumeral muscles which are responsible for stabilizing the humeral head. The biceps brachii muscle long and short head works as elbow flexor and forearm supinator. Its antagonist muscle is the triceps brachii muscle long head which extends the elbow as well as acts as an adductor of the elbow and of the humerus. Flexion and adduction of the humerus is performed by the coracobrachial muscle and the prime mover of the glenohumeral abduction, flexion, extension and adduction of the humerus is the deltoid muscle. The latissimus dorsi and teres major muscles perform adduction, internally rotation of the humerus in addition to rotation of the trunk (latissimus dorsi) and extension of the humerus (teres major)[44,64].

***Treatment***

In literature several different treatment algorithms have been developed based on bony defects, osteoarthritis and the physical state of patient[65-68]. In athletes, authors tend to be a bit more aggressive in terms of surgical procedures. Guehring *et al*[69] additionally considers the time interval between trauma and surgery. Conservative therapy is a reasonable initial treatment as one study demonstrated a subjective improvement after 6 mo in 70%-89% of patients. To avoid repetitive dislocation certain exercises (internal rotation and horizontal adduction) and activities should be avoided lifelong[70-72].

Directly after trauma, the shoulder should be kept in slight external or neutral rotation to avoid any stress to the posterior capsule. In physical therapy a general strengthening of the dynamic muscular stabilizers is essential. This includes the the rotator cuff - with focus on external rotation, infraspinatus muscle and teres minor -, the periscapular muscles - for scapulohumeral rhythm - as well as the posterior deltoid muscle[73]. Aim of physiotherapeutic exercises are to compensate the injured static structures of bone and tissue[68,74].

For postoperative care, various protocols have been described. The shoulder is immobilized with an orthosis in 30° of abduction and 0° of rotation to prevent internal rotation. Cryotherapy is recommended and active elevation should be avoided for at least 4 wk. In the following weeks, passive and active assisted movements are recommended, followed by full passive and active range of motion 2 to 3 mo after. When the muscle strength is at least 80% of the contralateral side a sport-specific rehabilitation program can be pursued and this is generally 6 months post-operatively[36,60,74].

As there are only a few evidence-based studies regarding treatment protocols and techniques it is difficult to develop a uniform algorithm.

The different treatment options such as conservative and operative treatment as well as success rates can be summarized in the table 2.

**CONCLUSION**

Posterior shoulder instability seems to be underdiagnosed due to its complexity and limited diagnostic examinations in general practice. So far no real consensus on classification of posterior shoulder instability exists. Moreover, the correct mechanism of injury is not well understood yet leading to a lack of consensus regarding treatment regimens and general awareness of physicians.

Posterior shoulder instability can be provoked according to the Kim/Jerk test in forward flexion, adduction and internal rotation. A variety of reasons for posterior shoulder instability have been described: The most important ones are capsular lesions, especially anterior one as well as ruptures of the IGHL. Patients, who suffered from posterior shoulder dislocation, mostly suffer from a rupture of the posterior capsule, loosening of the posterior labrum, and a rupture of the teres minor and/or infraspinatus tendon. This increases the risk of recurrent posterior shoulder instability especially in abduction between 0 to 90°. Further predisposing conditions, which have not been well investigated as of yet, include retroversion of the glenoid or of the humeral head.

The current treatment options vary in outcome in long term follow-up. Currently the best results have been observed using an arthroscopic capsulolabral repair in conjunction with a careful postoperative management with a delay in return to sport of about 4-6 mo.

With regards to the current biomechanical literature describing posterior shoulder dislocations, the predominant form on experimentation has used a static glenohumeral model. To our knowledge no dynamic model yet exists to investigate the entire shoulder complex including the scapulothoracic joint.

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**Table 1 The role of computed tomography scans and magnetic resonance imaging arthrograms and diagnostic rigour**

|  |  |  |
| --- | --- | --- |
|  | CT arthrography | MRI arthrography |
| Sensitivity | 82%-100%[75] | 48%-89%[76,77] |
| Specificity | 96%-100%[75] | 93%[77] |
| Advantage | Identifying bony lesions, severity of fractures, assess humeral and glenoid version[78] lower inter-examiner reliability[79] | Identifying the soft tissue from labrum to the rotator cuff[80], good for preoperative classification of labroligamentous injuries[81] |
| Disadvantage | Radiation  Small soft tissue lesions[82] | Limited in elderly patients[80] |
| Pathologies | Bony lesions/ fractures (Bankart fragments, Hill-Sachs Lesion)[82], [83]  Accurate in labroligamentous, cartilaginous lesions[75] | Avulsion of posterior periosteum[82]  Medial displacement of the labrum (posterior labro-scapular sleeve avulsion)[84]  Kim lesion - incomplete and concealed superficial tear in the posterior glenoid labrum  Glenoid rim articular divot lesion[7]  Chondral loose bodies[85] |

CT: Computed tomography; MRI: Magnetic resonance imaging.

**Table 2 Different therapeutic options and considerations of posterior shoulder instability**

|  |  |  |
| --- | --- | --- |
| Procedure | Consideration | Success rate |
| Conservative | Leads to loss of rotation and deformity of the shoulder, mainly performed in elderly patients | 68%-77%, however only in isolated posterior shoulder instability; recurrence rate up to 96%[38,86] |
| Capsular-labral repair (*i.e.*, post. - inf. capsular shift) or reverse Bankart repair | In isolated unidirectional posterior instability | 96% in post. – inf. capsular shift[73]  91% in posterior capsulorrhapy in isolated post. instability[5]  Posterior Bankart repair – 93%[87] |
| Other procedures not/ or rarely performed: |  |  |
| Thermal capsulorrhapy | High recurrence rate | 57%, capsular insufficiency 33%[88,89] |
| Posterior bone block or posterior wedge osteotomy | After failed capsular plication, or congenital formations | Posterior glenoid transfer: 53%; 41% complication rate[22,90]  Posterior bone block: 45%; 36% osteoarthritis[36] |
| McLaughlin’s procedure | In patients with locked posterior shoulder dislocation from reverse Hill-Sachs lesions | improvement in average constant scoring system from 16 preoperatively to 72 postoperatively[91] |
| Humeral head allograft | Alternative option to McLauglin’s procedure | Complication rate between 25%-50%[92/93] |

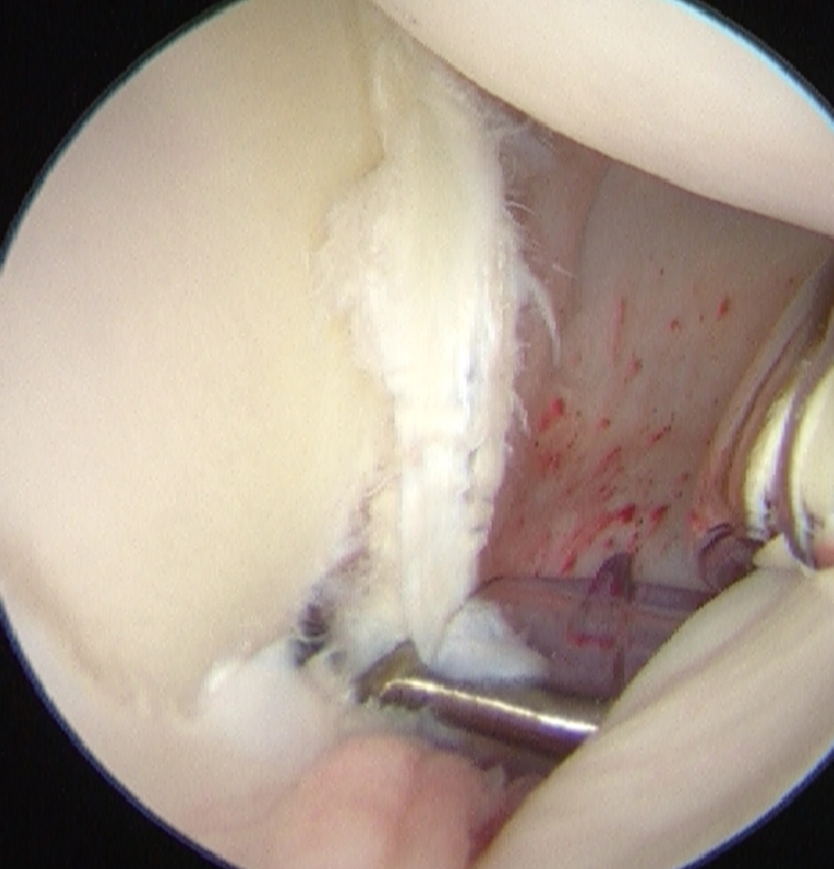
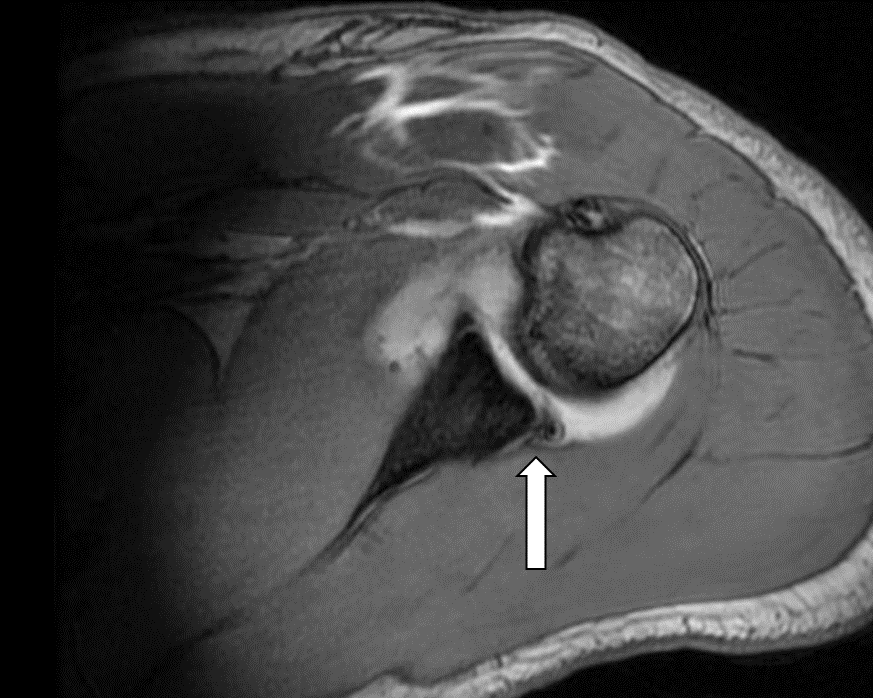
**Figure 1 Jerk test and Kim test.** A: Jerk test: The patient is sitting and the arm is flexed to 90˚ and internally rotated. An axial loading and horizontal adduction is applied; B: Kim test: The patient is sitting and the arm is abducted to 90˚ at the beginning. The examiner elevates the arm approximately 45˚ while applying postero-inferior force to the upper arm and axial load to the elbow. In a positive test, a subluxation of the glenohumeral joint can be observed.

**1AF:\submitted\Posterior Shoulder Stuff SUBMITTED\Jerk Test.tif**

**1B F:\submitted\Posterior Shoulder Stuff SUBMITTED\Kim Test.tif**

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**Figure 2** **Posterior labral tear.** A: Posterior labral tear in magnetic resonance arthrography; B: Intraoperative finding of posterior labral tear and posterior SLAP tear.

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