EFORT open reviews

SHOULDER AND ELBOW | 7:8 | 576–586

Comprehensive management of posterior shoulder instability: diagnosis, indications, and technique for arthroscopic bone block augmentation

Abdul-ilah Hachem[1], Andres Molina-Creixell[2], Xavier Rius[1], Karla Rodriguez-Bascones[3], Francisco Javier Cabo Cabo[1], Jose Luis Agulló[1] and Miguel Angel Ruiz-Iban[4]

[1]Department of Orthopedic Surgery, Bellvitge University Hospital, L'Hospitalet de Llobregat, Barcelona, Spain
[2]Tecnologico de Monterrey, Escuela de Medicina y Ciencias de la Salud, Monterrey, Mexico
[3]Department of Orthopedic Surgery, Asepeyo Hospital, Barcelona, Spain
[4]Ramón y Cajal University Hospital, Madrid, Spain

Correspondence should be addressed to A Hachem
Email
abelhachem@gmail.com

- Recurrent posterior glenohumeral instability is an entity that demands a high clinical suspicion and a detailed study for a correct approach and treatment. Its classification must consider its biomechanics, whether it is due to functional muscular imbalance or to structural changes, volition, and intentionality.
- Due to its varied clinical presentations and different structural alterations, ranging from capsule-labral lesions and bone defects to glenoid dysplasia and retroversion, the different treatment alternatives available have historically had a high incidence of failure.
- A detailed radiographic assessment, with both CT and MRI, with a precise assessment of glenoid and humeral bone defects and of glenoid morphology, is mandatory.
- Physiotherapy focused on periscapular muscle reeducation and external rotator strengthening is always the first line of treatment. When conservative treatment fails, surgical treatment must be guided by the structural lesions present, ranging from soft tissue repair to posterior bone block techniques to restore or increase the articular surface.
- Bone block procedures are indicated in cases of recurrent posterior instability after the failure of conservative treatment or soft tissue techniques, as well as symptomatic demonstrable nonintentional instability, presence of a posterior glenoid defect >10%, increased glenoid retroversion between 10 and 25°, and posterior rim dysplasia. Bone block fixation techniques that avoid screws and metal allow for satisfactory initial clinical results in a safe and reproducible way.
- An algorithm for the approach and treatment of recurrent posterior glenohumeral instability is presented, as well as the author's preferred surgical technique for arthroscopic posterior bone block.

Keywords

- shoulder
- instability
- posterior
- bone defect
- bone block

EFORT Open Reviews
(2022) **7**, 576–586

Introduction

Isolated posterior instability is reported as being the least common of all glenohumeral instabilities, representing from 2 to 10% of all cases (1, 2). In certain demographic groups, such as athletes in contact sports, rowers, climbers, and weightlifters, its incidence can be much higher, representing up to 24% of all young and active patients that are treated surgically for shoulder instability (2, 3, 4).

The structural and biomechanical characteristics of posterior instability, including an incompetent capsulolabral complex, glenoid dysplasia and retroversion, among others, make its diagnosis, classification and treatment more challenging than anterior instability (5). Also, due to the wide variety of clinical presentations, ranging from a painful, unstable shoulder with subluxations to recurrent complete glenohumeral luxation, and to the voluntary and non-voluntary nature of this pathology, there is no current treatment consensus, resulting in a high failure rate (3, 6).

Multiple surgical techniques for the treatment of recurring posterior instability have been described in the last decades (7). Currently, treatment strategies are focused on soft tissue repair, with capsulolabral reconstruction to restore the glenoid concavity and the posterior bumper

www.efortopenreviews.org
https://doi.org/10.1530/EOR-22-0009

effect, with or without reverse remplissage to address reverse Hill-Sachs lesions, having good clinical results in the absence of glenoid defects (8, 9). The presence of traumatic or erosive glenoid bone defects, a dysplastic glenoid rim, and a thin posterior capsule has increased the use of techniques with a bone graft (10, 11, 12, 13, 14). The use of opening wedge osteotomies and posterior bone block grafts, even in the absence of a bone defect, has been proposed by several authors to reduce the high failure rate after soft tissue repair (15, 16, 17). Arthroscopic techniques have gained popularity due to lower morbidity, the possibility to completely visualize the labrum and treat concomitant lesions, the prevention of deltoid deficiency, and advances in available instruments and implants (5, 12, 18).

In this review, an update in the clinical and radiographic assessment of recurrent posterior instability, its surgical indications, and an algorithm for its management and treatment are presented, while also describing an arthroscopic bone block technique with anatomic, metal-free fixation, and associated capsulolabral reconstruction for those cases in which it is indicated (12).

Clinical assessment

Patients with recurrent posterior shoulder instability will present with a characteristic history and clinical presentation. While posterior labral lesions can also yield pain and apprehension, posterior instability will additionally show a positive jerk and drawer tests, as well as recurrent subluxations and dislocations that can be reproduced by the patient or with provocative maneuvers.

Several factors determine the approach in patients with recurrent posterior instability. From a biomechanical standpoint, there must be a distinction between functional and structural posterior instability. *Functional shoulder instability* (FSI) is the result of a pathologic activation pattern of the scapulothoracic and rotator cuff muscles that leads to a posterior subluxation or dislocation of the humeral head, either during movement of the arm (positional FSI; predominantly in flexion, adduction, and internal rotation) or with the arm in a resting position (nonpositional FSI; with the arm in a neutral position), usually without resulting in lesions of the articular structures but potentially leading to anatomic and structural changes over time (19). *Structural instability* occurs as a consequence of posterior Bankart lesions, capsulo-labral insufficiency due to repetitive microtrauma, glenoid bone loss or reverse Hill-Sachs lesions that promote recurrent episodes of instability with the arm in flexion and internal rotation and axial loading (3). Other structural changes, which deserve special consideration, are glenoid dysplasia and retroversion since they can lead to the failure of soft tissue techniques when present and demand a different approach for their correction (20).

Another important consideration is the patient's ability to willfully control the instability episodes (voluntary or non-voluntary), making a special distinction between patients with voluntary instability due to psychological or affective disorders and those with demonstrable, non-voluntary instability (19). Surgical treatment of voluntary instability generally has poor results, regardless of the technique (5, 13, 21). These different clinical presentations, together with the possible structural lesions, demand an individualized treatment in each patient.

Radiographic assessment

All patients must be thoroughly studied with MRI and CT to identify any structural lesions, such as labral lesions, humeral or glenoid bone defects, and glenoid retroversion or dysplasia.

Evaluation of the glenoid defect is preferred in the CT parasagittal view, parallel to the joint line, in the immediate cut medial to the humeral head, by tracing a 'best-fit' circle on the glenoid surface that includes the two most peripheric points on the anterior and inferior glenoid rim to obtain its normal area in centimeter square. The area of the defect is then measured and reported as a percentage of the 'best-fit' circle's total area with the formula $D/A \times 100$ (D: defect area, A: 'best-fit' circle area) (22), as shown in Fig. 1A.

Measurement of the humeral defect, or reverse Hill-Sachs lesion, is made in the CT scan as described by Moroder *et al.* (23), using the axial cut in which the defect appears widest, and drawing a circle that matches the articular surface. The gamma angle is then measured from the bicipital groove to the center of the circle and to the medial border of the defect, as shown in Fig. 1B. If a glenoid defect is present, 2.3° must be added to the gamma angle for each millimeter, determined by measuring the glenoid diameter in the same axial cut and subtracting it from the 'best-fit' circle's diameter, obtained previously. A gamma angle >90% is considered an engaging lesion.

The axial CT allows visualization of the glenoid morphology, specifically the presence of dysplasia and retroversion. Edelson (24) and Weishaupt (25) described two different anatomic forms of posterior glenoid rim in recurrent posterior instability: the 'lazy-J' rounded glenoid deficiency and the triangular 'delta' bony deficiency. Glenoid retroversion can be determined using the Friedman method and is considered normal below 10° in the setting of recurrent posterior instability (Fig. 1C).

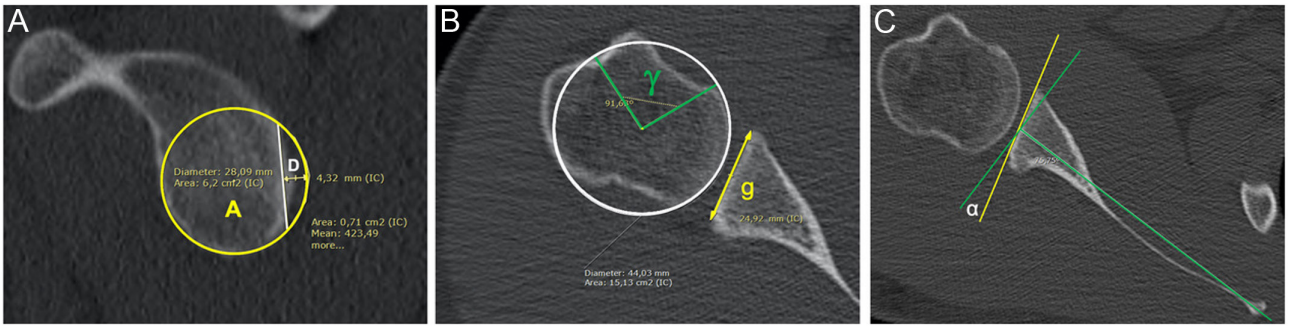

Figure 1

Preoperative CT of a shoulder with posterior instability and bone defect. (A) Sagittal cut immediately medial to the humeral head showing the 'best-fit circle'. (B) Gamma angle (γ) measurement in an axial cut. A circle matching the humeral articular surface is drawn (white circle), before measuring the angle formed from the center of the circle to the bicipital groove and to the medial border of the humeral defect (green lines). (C) Measurement of the glenoid retroversion in an axial cut using the Friedman method (α).

Treatment

Treatment of recurrent posterior instability should always include a physical therapy protocol, which consists of strengthening of the external rotators and periscapular muscles and can be aided with electrical stimulation to reeducate these muscles during shoulder and arm motion (26). When conservative treatment fails, surgical repair of capsulolabral lesions with soft tissue reconstruction techniques results in good clinical outcomes when there are minimal or no bone defects present, even in high-risk populations such as the military, contact sports, and athletes that are submitted to repetitive eccentric posterior glenoid loading (27, 28, 29). In contrast, in cases with traumatic, erosive, or dysplastic posterior glenoid defects, soft tissue repair alone presents a high incidence of failure, and bone graft reconstruction, open or arthroscopic, is the proposed treatment (30, 31).

The patients' ability to control the instability episodes, as described previously, marks a special distinction between two specific patient groups at opposite sides of the proposed treatment options. On one side, those with non-voluntary, demonstrable instability that are symptomatic and present with associated structural changes are candidates to posterior bone block techniques due to a high failure rate of soft tissue techniques. On the other side, the presence of voluntary instability must be considered a contraindication to surgical treatment and should continue with physical and psychological therapy, regardless of symptoms, as they have a very high risk of failure with any surgical intervention.

If symptoms persist after at least 6 months of physical therapy, in the form of isolated posterior instability or multidirectional instability with posterior predominance, the following factors need to be determined: the size of the glenoid defect, with the critical defect established at 11% (32), the size and characteristics of the humeral defect, with a gamma angle of 90° marking the threshold (33), and the presence of altered glenoid morphology (elevated retroversion and posterior rim dysplasia).

Treatment of the humeral defect

As in anterior instability, the presence of bipolar bone defects is one of the causes of persistent pain, failure, or recurrence in soft tissue repair techniques (21). Regarding the humeral defect, Moroder *et al.* (33) introduced the gamma angle concept, mentioned previously, and established a limit of 90° to predict engaging of the reverse Hill-Sachs lesion. These same authors described that, in the presence of a posterior glenoid defect, 2.3° should be added to the gamma angle for each millimeter measured in the axial plane, so that the presence of a glenoid defect can turn a non-engaging reverse Hill-Sachs into an engaging lesion (23). While no studies have correlated the gamma angle to an ideal treatment in the absence of a posterior glenoid defect, the current treatment of choice for an engaging humeral lesion with a gamma angle >90° is a reverse remplissage using the subscapularis tendon. Romano *et al.* (34) reported good clinical results in the Constant-Murley (CM) score, Western Ontario Shoulder Index (WOSI), and Subjective Shoulder Value (SSV) scores, as well as a statistically significant range of motion recovery, in 12 cases of chronic posterior dislocation with a minimum follow-up of 2 years treated with subscapularis remplissage using knotted implants. The authors' preferred technique is the knotless reverse remplissage, using suture tapes in a bridge configuration, fixed with two biodegradable screws, inserted through the tendon distally and over it proximally (8). This knotless subscapularis bridge technique has been performed in three patients, with good clinical results in two cases at 12 months and a recurrence in one of the cases that presented a bipolar post-traumatic defect with a 12% posterior glenoid erosion and a gamma angle >90°,

requiring a revision to a metal-free posterior bone block (unpublished data).

Treatment of the glenoid defect

The presence of a glenoid bone defect is a challenge due to the lack of consensus that defines the 'critical glenoid defect' that requires treatment in addition to soft tissue repair. The main reported risk factors for failure of isolated soft tissue surgery are female sex, dominant side, concomitant cuff injury, the use of three or fewer anchors in the repair, and a smaller glenoid diameter (35, 36). Nacca *et al.* (37), in a cadaveric model, found that an isolated reverse Bankart repair with a glenoid defect ≥20% is not sufficient to restore glenohumeral stability. More recently, Arner *et al.* (32) analyzed a group of 75 patients who underwent arthroscopic capsulolabral repair with a minimum follow-up of 24 months, finding in this group that a bone defect of 11% increased by 10.4 times the risk of failure, while a 15% defect increased it 24.4 times. Given the evidence of the direct relationship between the glenoid defect and the results of treatment of posterior instability, posterior bone block techniques have gained importance since they not only restore the glenoid surface but also the glenohumeral biomechanics, reducing posterior and posteroinferior translation of the humeral head (38).

Lafosse *et al.* (13) consider cases of recurrent post-traumatic posterior instability, the presence of humeral and/or glenoid defects, and cases of demonstrable non-voluntary instability with glenoid dysplasia or hypermobility as indications for a posterior bone block, without defining specific cuts in bone loss. For their part, Di Giacomo *et al.* (16) propose a glenoid defect ≥20% as the cut-off for these techniques. Moroder *et al.* (3), in their ABC classification of posterior instability, are even more specific, suggesting that the posterior bone block may be indicated in cases of functional posterior instability with failure of conservative treatment, in cases of structural posterior instability with glenoid defect, and in cases of constitutional or acquired static posterior instability.

Due to the low incidence of this pathology, there are few studies with long-term results. In a series of 18 patients with a minimum follow-up of 5 years (mean 7.3), Camenzind *et al.* (39) observed good long-term results with iliac crest autograft, with improvement in the CM score, American Shoulder and Elbow score (ASES), Walch-Duplay, Rowe and SSV. However, seven patients (37%) had to be reoperated due to symptomatic irritation of the screws. Other long-term studies report, in addition to the need for implant removal, complications such as graft lysis and the development of osteoarthrosis in up to a third of patients (40). Meuffels *et al.* (41), in a series of 11 patients treated with open posterior bone block and an 18-year follow-up, report a 36% recurrence rate and the development of glenohumeral osteoarthritis in all cases, associated with incongruous lateral graft placement and the presence of multidirectional instability or hypermobility.

Treatment of glenoid dysplasia and retroversion

Although the clinical relevance of dysplastic abnormalities and glenoid retroversion has not been defined, the combination of posteroinferior glenoid border deficiency and retroversion greater than 10° have been identified as risk factors for recurrence after soft tissue reconstruction (20). In a biomechanical study, Imhoff *et al.* (42) found that isolated labrum repair only had a significant effect on posterior centering and translation of the humeral head with <10° retroversion. However, the treatment focused on the correction of the glenoid version has not presented consistent results, in addition to being technically demanding. In a retrospective study of ten shoulders operated with an opening wedge osteotomy with a minimum follow-up of 2 years, Ortmaier *et al.* (43) reported a change in retroversion from 16 to 5°, without this influencing the posterior translation of the humeral head. In another study with seven patients treated with opening osteotomy and placement of the iliac crest J-graft, which seeks to correct the glenoid version and reconstruct the surface as a bone block simultaneously, Ernstbrunner *et al.* (15) obtained good clinical results, but limited function and persistent pain in two (28.5%) of the patients and progression of arthropathy and persistent apprehension in four(57%) of the patients. No clinical results have been published with posterior osteotomy or bone block in patients with type C glenoid (retroversion >25°) (15).

It cannot be ruled out that the reported progression to glenohumeral osteoarthritis, both in cases of posterior bone block and those with correction of the glenoid version, is a consequence of the static posterior subluxation of the humeral head, initially described by Walch *et al.* (17), which may be present even in the absence of osteoarthritis (recently defined as 'B0 glenoid' by the same authors) (44). Static posterior subluxation has a similar clinical presentation to instability, which can lead to underdiagnosis. It has also been shown to progress to osteoarthritis, regardless of the surgical technique. In a series of six patients treated surgically, the only one to present correction of the glenohumeral subluxation index was the one treated with posterior bone block and capsulorrhaphy (17).

Proposed treatment algorithm

Motivated by the lack of consensus, a general algorithm for the approach of recurrent posterior instability is presented in Fig. 2, based on the available literature and the accumulated experience in the treatment of this pathology.

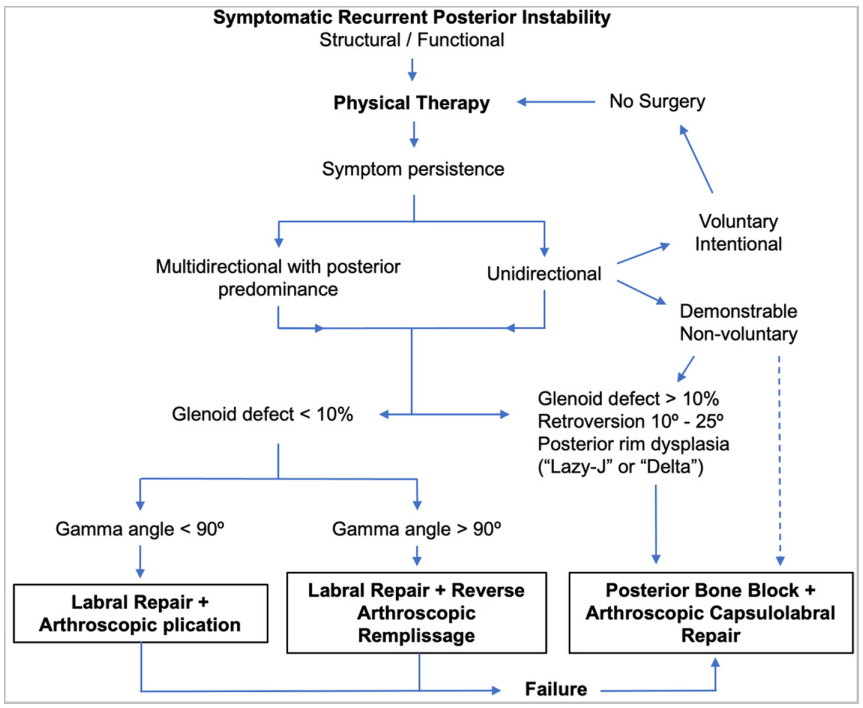

Figure 2
Treatment algorithm for patients with recurrent posterior glenohumeral instability.

Proposed surgical technique for posterior bone block augmentation

The indications and contraindications for bone block augmentation in recurrent posterior shoulder instability are summarized in Table 1. The following arthroscopic, metal-free bone block cerclage technique (Fig. 3) has the main advantages of being an all-arthroscopic technique, achieving an anatomic reconstruction of the glenoid concavity with an extra-articular graft, preserving bone stock by using small 2.4 mm tunnels and obtaining a metal-free fixation with high compression, and stability that mimics a plate. The disadvantages include that it is a technically demanding technique, recommended for advanced arthroscopic shoulder surgeons, and the requirement of special instruments.

Patient placement and arthroscopic diagnosis

The patient is placed in a lateral decubitus position, and arthroscopic diagnosis is started by introducing the scope through the standard posterior portal. All anatomical structures, as well as any concomitant injuries, are identified (SLAP (Superior Labrum Anterior to Posterior) lesion, anterior or inferior labrum lesions, etc.) before changing the scope to the anterosuperior portal for an optimal view of the posterior glenoid surface and to appropriately quantify the posterior glenoid bone loss (Fig. 4A).

Glenoid preparation

With the scope in the anterosuperior portal, the posteroinferior capsulolabral complex is released from 11 to 6 o'clock. The released tissue is temporarily secured with a polydioxanone suture introduced with a SutureLasso (Arthrex) through a posterolateral accessory portal. This gesture allows an optimal view of the posterior glenoid defect. The edge of the posterior glenoid is debrided to ensure the biological integration of the graft. Once a bleeding glenoid edge is achieved, the glenoid bone defect is measured with an arthroscopic measurement tool (Arthroscopic Measurement Probe, 220 mm, 60°, Arthrex) introduced through the posterior portal. The mid-point of the posterior glenoid bone loss is marked as a reference point for the drill guide placement (Fig. 4D).

Table 1 Indications and contraindications for bone block augmentation in symptomatic recurrent posterior shoulder instability.

Indications
• Posterior erosive glenoid bone loss >10% of the best-fit circle
• Abnormal glenoid retroversion 10–25°
• Posterior rim dysplasia in a 'Lazy-J' or 'Delta' glenoid shape
• Failure of previous soft tissue procedure
• Functional, unidirectional, and demonstrable non-voluntary instability with structural changes
Contraindications
• Voluntary posterior instability
• Multidirectional instability
• Static posterior subluxation 'Walch B0'

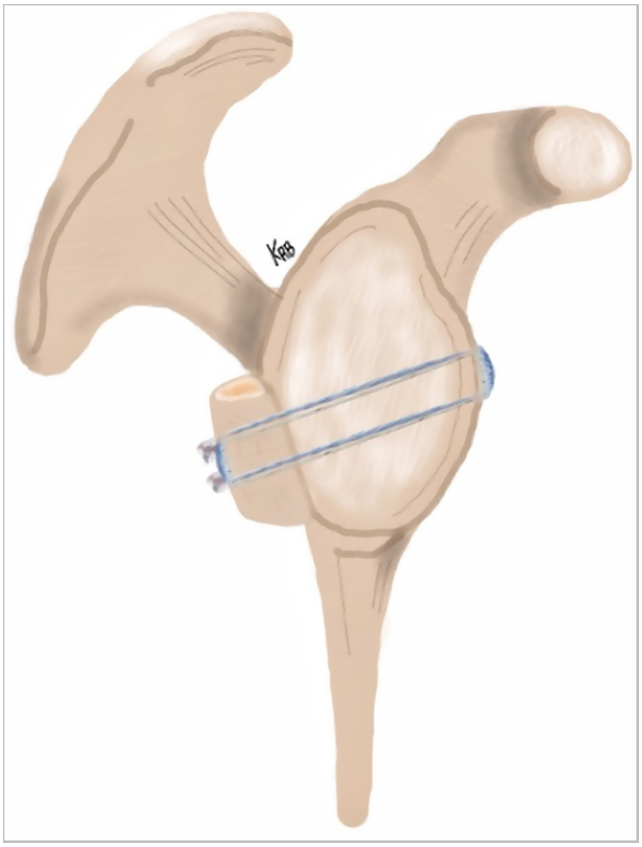

Figure 3
Graphic representation of the 'Posterior Bone Block Cerclage' technique. Using a system of ultra-high strength tapes without metal, the posterior bone defect is reconstructed with an iliac crest bone graft. Interconnection of the tapes over the graft's cortical surface, associated to the use of a mechanical tensioner, achieves a strong and stable fixation parallel to the native glenoid surface.

Glenoid tunnel drilling

From the standard posterior portal, a needle is introduced as a guide to the correct placement of the specific drill guide (Arthrex) (Fig. 4B and C), which should be parallel to the glenoid surface and in line with the mid-point of the posterior glenoid bone defect. When the drill guide is in contact with the glenoid, two perforations are made using 1.5-mm K-wires with the predetermined distance of 10 mm, exposing their exit points in the anterior glenoid through the anterior capsule (usually located between 1 and 4 o'clock), posterior to the subscapularis tendon (Fig. 4E and F). The two glenoid tunnels are made over the K-wires using 2.4-mm cannulated drills (Fig. 4G, H, and I). The K-wires are replaced with nitinol wire loops, which are used to place two transport sutures with the loops facing in opposite directions (Fiberlink/Tigerlink, Arthrex). The distance between the distal tunnel and the inferior edge of the defect, and the distance between both tunnels and the glenoid surface, is measured before preparing the graft (Fig. 4J, K, and L).

Graft preparation

The graft is prepared using an oscillating saw to adapt it to the measurements taken previously, leaving the cancellous surface to sit against the glenoid and choosing the cortical surface that most closely matches the glenoid articular surface. Typically, the graft measures around 20–25 mm in length, is 8–10 mm wide, and 10–12 mm thick. The tricortical thickness of the graft is anatomically conditioned and it is not modified. Using the 2.4-mm drill, two tunnels from the cancellous to the cortical side are created, coinciding with the previously measured distance between the inferior glenoid tunnel and the inferior margin of the bone loss area. The superior tunnel is then drilled 10 mm proximal to the inferior tunnel (predetermined by the drill guide). The distance between both tunnels and the articular side of the graft should match the distance between the glenoid tunnels and the glenoid articular surface. This way, the bone block may be in total continuity and congruency with the cartilage of the glenoid.

Graft placement and fixation

The standard posterior portal (or accessory portal, when necessary) is dilated manually to facilitate graft introduction. Two ultra-high-strength tape cerclage systems (FiberTape/TigerTape Cerclage Suture, Arthrex) are shuttled through the tunnels to create the cerclage construct using the transport sutures placed previously, starting from the cortical side of the first graft tunnel, next from posterior to anterior through the corresponding glenoid tunnel and recovered in the anterior cannula, back from anterior to posterior through the second glenoid tunnel and finally from the cancellous to the cortical side of the second graft tunnel. This construct of ultra-high-strength tape cerclage systems forms a cerclage assembly for graft fixation (Fig. 5A, B, C, D, E, and F).

The graft can be introduced directly through the dilated posterior portal or placing a 10 mL syringe acting as a cannula to facilitate its introduction into the joint (Fig. 5B, C, and D). Once the graft is correctly positioned (congruent to the glenoid surface), the cerclage assembly is finalized by interconnecting the ultra-high-strength tape cerclage sutures (Fig. 5B). The knots are reduced to the cortical edge of the graft by applying alternating symmetric traction of the interconnected tapes (Fig. 5F).

After obtaining adequate stability of the bone block with manual traction, a mechanical tensioner (FiberTape Cerclage Tensioner, Arthrex) is used to apply a progressive force of 50–60 lb, alternating in each knot. Finally, three alternating half hitch knots are used to lock each system, ensuring a strong and stable fixation.

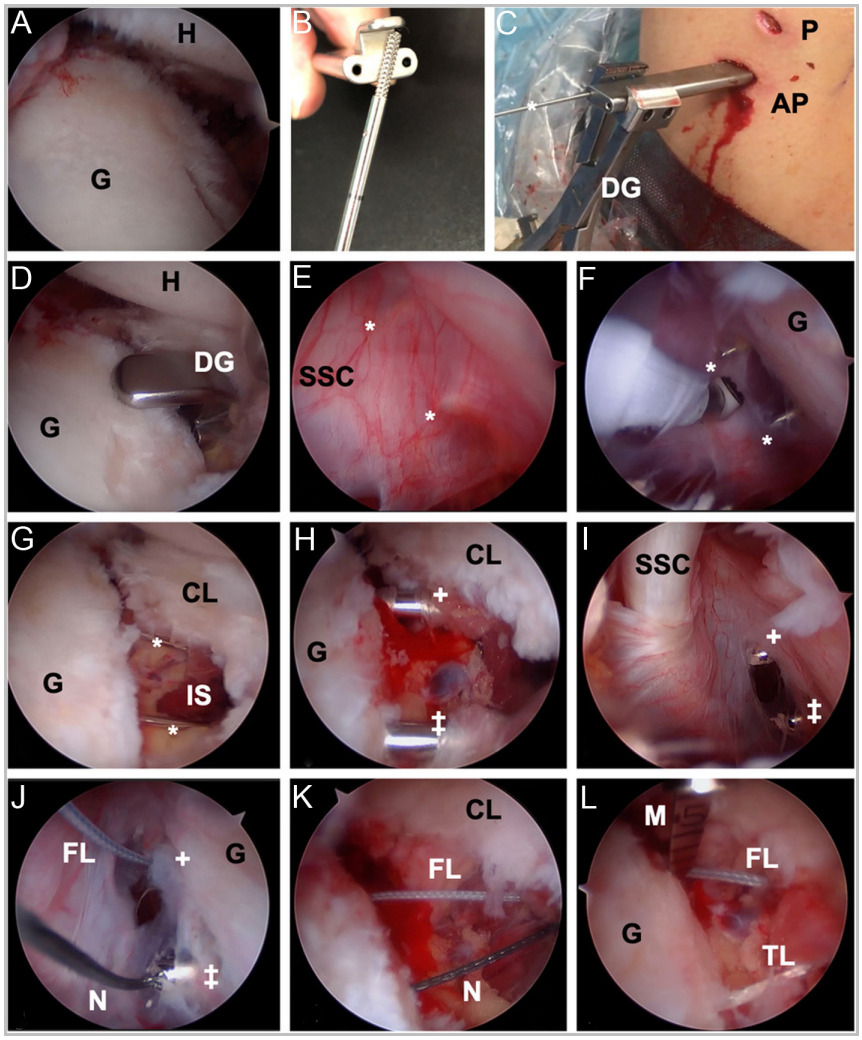

Figure 4
Glenoid preparation and tunnel drilling. (A, B, C, D, E, F, G, H, I, J, K, and L) Right shoulder, patient in lateral decubitus position, arthroscopic view from the anterosuperior portal. After release of the posterior capsulolabral complex from the glenoid rim, a drilling guide is placed parallel to the articular surface, using an accessory posterior portal when necessary. Two K-wires are then drilled into the glenoid using the guide, identifying their exit point through the anterior capsule and posterior to the subscapularis tendon. Two 2.4 mm canulated drills are then used to create the tunnels over the K-wires, before using a nitinol wire loop to replace each drill with a transport suture loop, in such a way that one loop faces anteriorly and the other posteriorly. +, inferior cannulated drill; ‡, superior cannulated drill; *, K-wires. AP, accessory posterior portal; CL, capsulolabral complex; DG, drill guide; FL, Fiberlink; G, glenoid; H, humeral head; IS, infraspinatus; M, arthroscopic measuring probe; N, nitinol wire loop; P, posterior portal; SSC, subscapularis; TL, Tigerlink.

Capsulolabral repair

The posterior capsulolabral complex is repaired to the debrided glenoid edge, using 1.8 mm all-suture anchors (FiberTak suture anchors, Arthrex). Usually, three or four anchors between 6 and 10 o'clock are needed to ensure an anatomical repair of the capsulolabral complex, leaving the graft extraarticular (Fig. 5G, H and I).

Rehabilitation and radiographic follow-up

Postoperatively, the arm is placed in a shoulder immobilizer device in neutral rotation and 15° of abduction during the first 3 weeks. During this period, the patient is allowed to perform pendulum exercises, assisted flexion passive motion, deltoid isometric exercises, and rehabilitation of scapular stabilizers. From the third to sixth weeks, the rehabilitation program is directed to restoring the full range of motion with passive assisted exercises and active exercises without resistance. Starting at the sixth week, active range of motion with resistance is allowed. When the full range of motion and 90% of strength (compared to contralateral shoulder) are achieved, the patient is allowed to return to previous sports activities, which usually occurs between the fourth and fifth month after surgery.

X-ray follow-up is done with AP and Bernageau projections at the third and sixth weeks, and posteriorly, at the third, sixth, and 12th months. Also, a CT is performed during the immediately postoperative period and around the first-year post-surgery (Fig. 6).

Results

This bone block technique has been performed by the authors in eight patients with posterior shoulder instability after the failure of conservative treatment, of which six had a nontraumatic onset and only three had no bone defect. Both cases of traumatic origin presented a posterior glenoid defect, and one of them presented a bipolar bone defect, which led to a recurrence after an initial subscapularis remplissage that was later revised to a posterior bone block procedure. Four patients presented

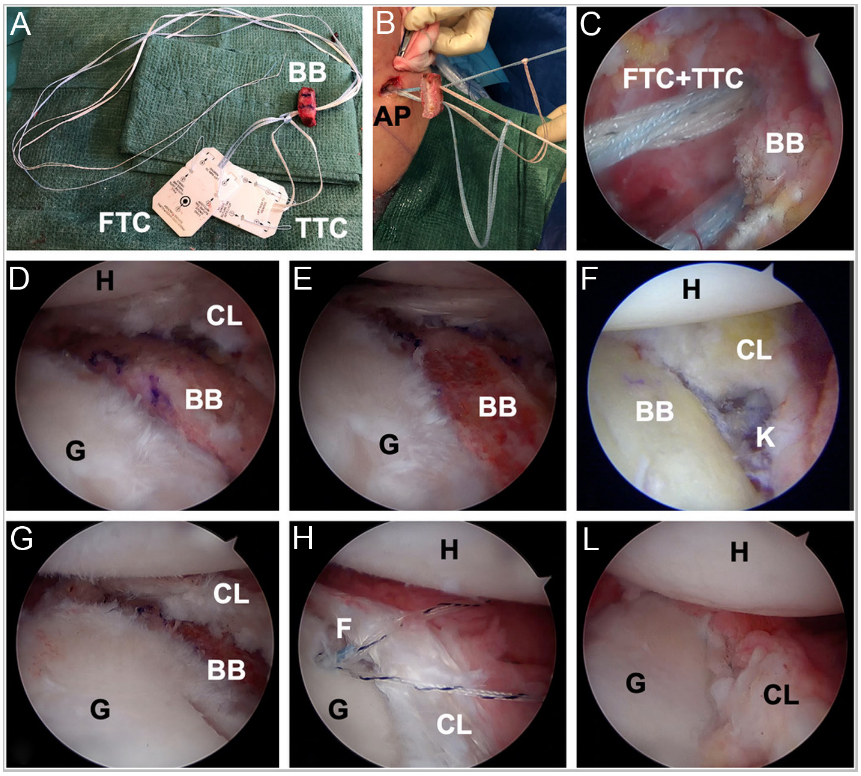

Figure 5
Graft placement and capsulolabral complex repair. (A and B) Extra articular view showing graft preparation, cerclage fixation system and the interconnection of the pre-formed, racking hitch knots. (C, D, E, F, G, H, and I) Right shoulder, patient in lateral decubitus position, arthroscopic view from the anterosuperior portal. Using the transport sutures in the glenoid tunnels, two ultra-high-strength tape cerclage systems are transported through the graft and the glenoid, first into the graft from the cortical surface to the cancellous side, then from posterior to anterior in the first glenoid tunnel, returning from anterior to posterior in the second glenoid tunnel and finally through the second graft tunnel from the cancellous to the cortical side. The tape cerclage systems are interconnected with the pre-formed knots and the graft is placed into the joint, locking the system with additional manual knots. Finally, the capsulolabral complex is repaired to the native glenoid, leaving the graft in an extra-articular position. AP, accessory posterior portal; BB, iliac crest bone block; CL, capsulolabral complex; F, Fibertak; FTC, Fibertape Cerclage; H, humeral head; K, locking knot; TTC, Tigertape Cerclage.

local hypermobility of the shoulder, including one of the traumatic cases. Of these, one had a 16° retroversion and the other had a 'lazy-J' dysplasia of the posteroinferior rim together with hypoplasia of the labrum, which was deemed the cause of failure of the previous arthroscopic surgery. Furthermore, three of the patients without bone defects could demonstrate posterior instability (the patients with retroversion, dysplasia, and the last one with multidirectional instability of inferior predominance). Patient characteristics are summarized in Table 2. Follow-up ranged from 12 to a maximum of 28 months, with graft

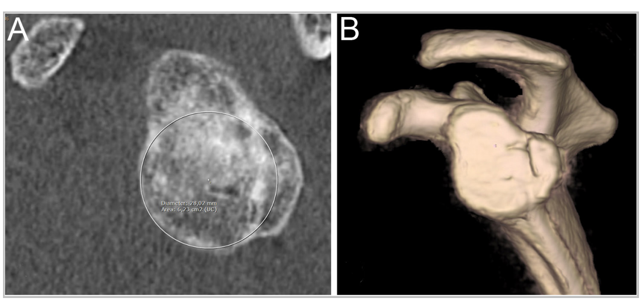

Figure 6
Twelve-month follow-up CT of a patient treated with posterior bone block. (A) Sagittal cut with the preoperative 'best-fit circle' superimposed, showing adequate restoration of the glenoid surface and graft consolidation. (B) 3D reconstruction.

consolidation in all cases between 2 and 4 months seen with a Bernageau projection. No patient presented any short-term complications beyond the initial discomfort of the graft donor site in the iliac crest.

Two out of eight patients (25%) presented with worsening of functional scores, affected by the worker compensation status in one (patient 6) and an underestimated posterior static shoulder subluxation, Walch B0, in the other (patient 7). In the remaining six patients, scores improved in the WOSI (1315 to 391, P=0.007), Rowe (39.1 to 95, P=0.001), CM score (69.4 to 89.5, P=0.04), and SSV (30 to 85, P = 0.003). By modifying the indications, as proposed in Table 1, and the use of a metal-free cerclage fixation, this small patient cohort presented a lower failure rate and less hardware complications than those reported by Cogneti *et al.* (45) and Mojica *et al.* (46), respectively. Further mid- to long-term studies are necessary to further evaluate these clinical results.

Conclusion

Advances in the diagnosis, classification, and a treatment algorithm that considers laxity, direction, arm position, intentionality, and the presence of structural defects contribute to a consistent approach and satisfactory clinical

Table 2 Posterior bone block augmentation – patient characteristics.

No.	Onset	Demonstrable instability	Shoulder hypermobility	Glenoid defect > 10%	Glenoid rim dysplasia	Retroversion	Failed previous surgery	Poor posterior soft tissue
1	Non-Traumatic	–	–	Yes	–	–	–	–
2	Non-Traumatic	Yes	Yes	–	–	–	–	Yes
3	Non-Traumatic	Yes	Yes	–	–	Yes	–	–
4	Non-Traumatic	–	–	Yes	–	–	Yes	–
5	Non-Traumatic	Yes	Yes	–	Yes	–	Yes	–
6	Traumatic	–	–	Yes	–	–	Yes	–
7	Traumatic	Yes	Yes	Yes	–	–	–	–
8	Non-Traumatic	Yes	–	Yes	–	–	Yes	Yes

results in patients with recurrent posterior glenohumeral instability. Arthroscopic bone block techniques can achieve anatomical restoration of the glenoid defect, a congruent augmentation of the articular surface, and an associated capsulolabral repair in patients with non-voluntary, demonstrable, and symptomatic posterior instability, regardless of the primary cause.

The development of new techniques and arthroscopic implants, such as fixation using tape cerclages for the bone block presented in this article, seeks to offer safe and reproducible techniques that eliminate the complications related to the use of metal implants and facilitate radiographic follow-up. The results included in this article represent a short-term evaluation of a new technique in a small population. Longer observation and larger series of patients are needed to confirm these encouraging early results in this difficult patient population.

ICMJE Conflict of Interest Statement
The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported.

Funding Statement
This work did not receive any specific grant from any funding agency in the public, commercial, or not-for-profit sector.

References

1. Woodmass JM, Lee J, Wu IT, Desai VS, Camp CL, Dahm DL & Krych AJ. Incidence of posterior shoulder instability and trends in surgical reconstruction: a 22-year population-based study. *Journal of Shoulder and Elbow Surgery* 2019 **28** 611–616. (https://doi.org/10.1016/j.jse.2018.08.046)

2. Provencher MT, Leclere LE, King S, McDonald LS, Frank RM, Mologne TS, Ghodadra NS & Romeo AA. Posterior instability of the shoulder: diagnosis and management. *American Journal of Sports Medicine* 2011 **39** 874–886. (https://doi.org/10.1177/0363546510384232)

3. Moroder P & Scheibel M. ABC classification of posterior shoulder instability. *Obere Extremitat* 2017 **12** 66–74. (https://doi.org/10.1007/s11678-017-0404-6)

4. Chang ES, Greco NJ, McClincy MP & Bradley JP. Posterior shoulder instability in overhead athletes. *Orthopedic Clinics of North America* 2016 **47** 179–187. (https://doi.org/10.1016/j.ocl.2015.08.026)

5. Frank RM, Romeo AA & Provencher MT. Posterior glenohumeral instability: evidence-based treatment. *Journal of the American Academy of Orthopaedic Surgeons* 2017 **25** 610–623. (https://doi.org/10.5435/JAAOS-D-15-00631)

6. Clavert P, Furioli E, Andieu K, Sirveaux F, Hardy MB, Nourissat G, Bouju Y, Garret J, Godenèche A, Mansat P, *et al.* Clinical outcomes of posterior bone block procedures for posterior shoulder instability: multicenter retrospective study of 66 cases. *Orthopaedics and Traumatology, Surgery and Research* 2017 **103** S193–S197. (https://doi.org/10.1016/j.otsr.2017.08.006)

7. DiMaria S, Bokshan SL, Nacca C & Owens B. History of surgical stabilization for posterior shoulder instability. *JSES Open Access* 2019 **3** 350–356. (https://doi.org/10.1016/j.jses.2019.08.008)

8. Hachem AI, Bascones KR, Costa D'O G, Rondanelli S R & Rius X. Arthroscopic knotless subscapularis bridge technique for reverse hill-Sachs lesion with posterior shoulder instability. *Arthroscopy Techniques* 2021 **10** e103–e116. (https://doi.org/10.1016/j.eats.2020.09.016)

9. Alepuz ES, Pérez-Barquero JA, Jorge NJ, García FL & Baixauli VC. Treatment of the posterior unstable shoulder. *Open Orthopaedics Journal* 2017 **11** 826–847. (https://doi.org/10.2174/1874325001711010826)

10. Schwartz DG, Goebel S, Piper K, Kordasiewicz B, Boyle S & Lafosse L. Arthroscopic posterior bone block augmentation in posterior shoulder instability. *Journal of Shoulder and Elbow Surgery* 2013 **22** 1092–1101. (https://doi.org/10.1016/j.jse.2012.09.011)

11. Boileau P, Hardy MB, McClelland WB, Thélu CE & Schwartz DG. Arthroscopic posterior bone block procedure: a new technique using suture anchor fixation. *Arthroscopy Techniques* 2013 **2** e473–e477. (https://doi.org/10.1016/j.eats.2013.07.004)

12. Hachem AI, Rondanelli R, Costa D'O G, Verdalet I & Rius X. Arthroscopic'bone block cerclage' technique for posterior shoulder instability. *Arthroscopy Techniques* 2020 **9** e1171–e1180. (https://doi.org/10.1016/j.eats.2020.04.017)

13. Lafosse L, Franceschi G, Kordasiewicz B, Andrews WJ & Schwartz D. Arthroscopic posterior bone block: surgical technique. *Musculoskeletal Surgery* 2012 **96** 205–212. (https://doi.org/10.1007/s12306-012-0220-5)

14. Wellmann M, Pastor MF, Ettinger M, Koester K & Smith T. Arthroscopic posterior bone block stabilization-early results of an effective procedure for the recurrent posterior instability. *Knee Surgery, Sports Traumatology, Arthroscopy* 2018 **26** 292–298. (https://doi.org/10.1007/s00167-017-4753-x)

15. Ernstbrunner L, Häller T, Waltenspül M, Wieser K & Gerber C. Posterior open-wedge osteotomy and glenoid concavity reconstruction using an implant-free, J-shaped iliac crest bone graft in atraumatic posterior instability with pathologic glenoid retroversion and dysplasia: a preliminary report. *Clinical Orthopaedics and Related Research* 2021 **479** 1995–2005. (https://doi.org/10.1097/CORR.0000000000001757)

16. di Giacomo G, Piscitelli L & Pugliese M. The role of bone in glenohumeral stability. *EFORT Open Reviews* 2018 **3** 632–640. (https://doi.org/10.1302/2058-5241.3.180028)

17. Walch G, Ascani C, Boulahia A, Nové-Josserand L & Edwards TB. Static posterior subluxation of the humeral head: an unrecognized entity responsible for glenohumeral osteoarthritis in the young adult. *Journal of Shoulder and Elbow Surgery* 2002 **11** 309–314. (https://doi.org/10.1067/mse.2002.124547)

18. Barbier O, Ollat D, Marchaland JP & Versier G. Iliac bone-block autograft for posterior shoulder instability. *Orthopaedics and Traumatology, Surgery and Research* 2009 **95** 100–107. (https://doi.org/10.1016/j.otsr.2008.09.008)

19. Moroder P, Danzinger V, Maziak N, Plachel F, Pauly S, Scheibel M & Minkus M. Characteristics of functional shoulder instability. *Journal of Shoulder and Elbow Surgery* 2020 **29** 68–78. (https://doi.org/10.1016/j.jse.2019.05.025)

20. Eichinger JK, Galvin JW, Grassbaugh JA, Parada SA & Li X. Glenoid dysplasia: pathophysiology, diagnosis, and management. *Journal of Bone and Joint Surgery: American Volume* 2016 **98** 958–968. (https://doi.org/10.2106/JBJS.15.00916)

21. Servien E, Walch G, Cortes ZE, Edwards TB & O'Connor DP. Posterior bone block procedure for posterior shoulder instability. *Knee Surgery, Sports Traumatology, Arthroscopy* 2007 **15** 1130–1136. (https://doi.org/10.1007/s00167-007-0316-x)

22. Sugaya H, Moriishi J, Dohi M, Kon Y & Tsuchiya A. Glenoid rim morphology in recurrent anterior glenohumeral instability. *Journal of Bone and Joint Surgery: American Volume* 2003 **85** 878–884. (https://doi.org/10.2106/00004623-200305000-00016)

23. Moroder P, Plachel F, Tauber M, Habermeyer P, Imhoff A, Liem D, Lill H, Resch H, Gerhardt C & Scheibel M. Risk of engagement of bipolar bone defects in posterior shoulder instability. *American Journal of Sports Medicine* 2017 **45** 2835–2839. (https://doi.org/10.1177/0363546517714456)

24. Edelson JG. Localized glenoid hypoplasia: an anatomic variation of possible clinical significance. *Clinical Orthopaedics and Related Research* 1995 **321** 189–195. (https://doi.org/10.1097/00003086-199512000-00029)

25. Weishaupt D, Zanetti M, Nyffeler RW, Gerber C & Hodler J. Posterior glenoid rim deficiency in recurrent (atraumatic) posterior shoulder instability. *Skeletal Radiology* 2000 **29** 204–210. (https://doi.org/10.1007/s002560050594)

26. Moroder P, Plachel F, Van-Vliet H, Adamczewski C & Danzinger V. Shoulder-pacemaker treatment concept for posterior positional functional shoulder instability: a prospective clinical trial. *American Journal of Sports Medicine* 2020 **48** 2097–2104. (https://doi.org/10.1177/0363546520933841)

27. Kim SH, Ha KI, Park JH, Kim YM, Lee YS, Lee JY & Yoo JC. Arthroscopic posterior labral repair and capsular shift for traumatic unidirectional recurrent posterior subluxation of the shoulder. *Journal of Bone and Joint Surgery: American Volume* 2003 **85** 1479–1487. (https://doi.org/10.2106/00004623-200308000-00008)

28. Chan S, O'Brien LK, Waterman BR, Chan AG, Pallis M & Kilcoyne KG. Low risk of recurrence after posterior labral repair of the shoulder in a high-risk United States military population. *Arthroscopy, Sports Medicine, and Rehabilitation* 2020 **2** e47–e52. (https://doi.org/10.1016/j.asmr.2019.10.008)

29. DeLong JM, Jiang K & Bradley JP. Posterior instability of the shoulder: a systematic review and meta-analysis of clinical outcomes. *American Journal of Sports Medicine* 2015 **43** 1805–1817. (https://doi.org/10.1177/0363546515577622)

30. Mauro CS, McClincy MP & Bradley JP. Effect of glenoid version and width on outcomes of arthroscopic posterior shoulder stabilization. *American Journal of Sports Medicine* 2016 **44** 941–947. (https://doi.org/10.1177/0363546516631738)

31. Fuchs B, Jost B & Gerber C. Posterior-inferior capsular shift for the treatment of recurrent, voluntary posterior subluxation of the shoulder. *Journal of Bone and Joint Surgery: American Volume* 2000 **82** 16–25. (https://doi.org/10.2106/00004623-200001000-00003)

32. Arner JW, Ruzbarsky JJ, Midtgaard K, Peebles L, Bradley JP & Provencher MT. Defining critical glenoid bone loss in posterior shoulder capsulolabral repair. *American Journal of Sports Medicine* 2021 **49** 2013–2019. (https://doi.org/10.1177/03635465211016804)

33. Moroder P, Runer A, Kraemer M, Fierlbeck J, Niederberger A, Cotofana S, Vasvari I, Hettegger B, Tauber M, Hurschler C, *et al.* Influence of defect size and localization on the engagement of reverse hill-sachs lesions. *American Journal of Sports Medicine* 2015 **43** 542–548. (https://doi.org/10.1177/0363546514561747)

34. Romano AM, Edwards TB, Nastrucci G, Casillo P, Di Giunta A, Zappia M, Susanna M & Ascione F. Arthroscopic reduction and subscapularis remplissage (ARR) of chronic posterior locked shoulder dislocation leads to optimized outcomes and low rate of complications. *Knee Surgery, Sports Traumatology, Arthroscopy* 2021 **29** 2348–2355. (https://doi.org/10.1007/s00167-020-06317-6)

35. Bradley JP, Arner JW, Jayakumar S & Vyas D. Revision arthroscopic posterior shoulder capsulolabral repair in contact athletes: risk factors and outcomes. *Arthroscopy* 2020 **36** 660–665. (https://doi.org/10.1016/j.arthro.2019.09.029)

36. Bradley JP, Arner JW, Jayakumar S & Vyas D. Risk factors and outcomes of revision arthroscopic posterior shoulder capsulolabral repair. *American Journal of Sports Medicine* 2018 **46** 2457–2465. (https://doi.org/10.1177/0363546518785893)

37. Nacca C, Gil JA, Badida R, Crisco JJ & Owens BD. Critical glenoid bone loss in posterior shoulder instability. *American Journal of Sports Medicine* 2018 **46** 1058–1063. (https://doi.org/10.1177/0363546518758015)

38. Wellmann M, Bobrowitsch E, Khan N, Patzer T, Windhagen H, Petersen W & Bohnsack M. Biomechanical effectiveness of an arthroscopic posterior Bankart repair versus an open bone block procedure for posterior shoulder instability. *American Journal of Sports Medicine* 2011 **39** 796–803. (https://doi.org/10.1177/0363546510389991)

39. Camenzind RS, Martin Becerra J, Gossing L, Serane-Fresnel J, Wagner ER & Lafosse L. Acceptable long-term outcomes of arthroscopic bone grafting for recurrent posterior shoulder instability: minimum follow-up of 5 years. *Arthroscopy* 2021 **37** 816–823. (https://doi.org/10.1016/j.arthro.2020.10.052)

40. Cerciello S, Visonà E, Morris BJ & Corona K. Bone block procedures in posterior shoulder instability. *Knee Surgery, Sports Traumatology, Arthroscopy* 2016 **24** 604–611. (https://doi.org/10.1007/s00167-015-3607-7)

41. Meuffels DE, Schuit H, van Biezen FC, Reijman M & Verhaar JA. The posterior bone block procedure in posterior shoulder instability: a long-term follow-up study. *Journal of Bone and Joint Surgery: British Volume* 2010 **92** 651–655. (https://doi.org/10.1302/0301-620X.92B5.23529)

42. Imhoff FB, Camenzind RS, Obopilwe E, Cote MP, Mehl J, Beitzel K, Imhoff AB, Mazzocca AD, Arciero RA & Dyrna FGE. Glenoid retroversion is an important factor for humeral head centration and the biomechanics of posterior shoulder stability. *Knee Surgery, Sports Traumatology, Arthroscopy* 2019 **27** 3952–3961. (https://doi.org/10.1007/s00167-019-05573-5)

43. Ortmaier R, Moroder P, Hirzinger C & Resch H. Posterior open wedge osteotomy of the scapula neck for the treatment of advanced shoulder osteoarthritis with posterior head

migration in young patients. *Journal of Shoulder and Elbow Surgery* 2017 **26** 1278–1286. (https://doi.org/10.1016/j.jse.2016.11.005)

44. Domos P, Checchia CS & Walch G. Walch B0 glenoid: pre-osteoarthritic posterior subluxation of the humeral head. *Journal of Shoulder and Elbow Surgery* 2018 **27** 181–188. (https://doi.org/10.1016/j.jse.2017.08.014)

45. Cognetti DJ, Hughes JD, Kay J, Chasteen J, Fox MA, Hartzler RU, Lin A & Sheean AJ. Bone block augmentation of the posterior glenoid for recurrent posterior shoulder instability is associated with high rates of clinical failure: a systematic review. *Arthroscopy* 2022 **38** 551.e5–563.e5. (https://doi.org/10.1016/j.arthro.2021.07.018)

46. Mojica ES, Schwartz LB, Hurley ET, Gonzalez-Lomas G, Campbell KA & Jazrawi LM. Posterior glenoid bone block transfer for posterior shoulder instability: a systematic review. *Journal of Shoulder and Elbow Surgery* 2021 **30** 2904–2909. (https://doi.org/10.1016/j.jse.2021.06.013)