■ SHOULDER & ELBOW

Management of bone loss in anterior shoulder instability

CURRENT STATE OF THE ART AND FUTURE DIRECTIONS

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Bone defects are frequently observed in anterior shoulder instability. Over the last decade, knowledge of the association of bone loss with increased failure rates of soft-tissue repair has shifted the surgical management of chronic shoulder instability. On the glenoid side, there is no controversy about the critical glenoid bone loss being 20%. However, poor outcomes have been described even with a subcritical glenoid bone defect as low as 13.5%. On the humeral side, the Hill-Sachs lesion should be evaluated concomitantly with the glenoid defect as the two sides of the same bipolar lesion which interact in the instability process, as described by the glenoid track concept. We advocate adding remplissage to every Bankart repair in patients with a Hill-Sachs lesion, regardless of the glenoid bone loss. When critical or subcritical glenoid bone loss occurs in active patients (> 15%) or bipolar off-track lesions, we should consider anterior glenoid bone reconstructions. The techniques have evolved significantly over the last two decades, moving from open procedures to arthroscopic, and from screw fixation to metal-free fixation. The new arthroscopic techniques of glenoid bone reconstruction procedures allow precise positioning of the graft, identification, and treatment of concomitant injuries with low morbidity and faster recovery. Given the problems associated with bone resorption and metal hardware protrusion, the new metal-free techniques for Latarjet or free bone block procedures seem a good solution to avoid these complications, although no long-term data are yet available.

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Introduction

The bony structure of the glenohumeral joint is often described as a golf ball and tee, which allows an ample arc of motion at the cost of joint stability.[1] The incidence of primary shoulder dislocation is 1.7% in the general population, with traumatic anterior shoulder instability being the most common type, accounting for > 90% of the cases.[2,3] Soft-tissue injuries (labrum and glenohumeral ligaments) are almost always damaged in major shoulder dislocation, but awareness of bone loss has increased. Kurokawa et al[4] reported that 86% of first-time dislocations result in glenoid bone defects, and 94% result in Hill-Sachs lesions, with 81% of them showing both (termed bipolar lesions). In recurrent instability, up to 90% of patients demonstrate either glenoid or humeral head bone loss.[5] Over the last decade, knowledge of the association of bone loss with the rate of failure of soft-tissue repair has shifted the surgical management of chronic shoulder instability.[6-9]

Evaluation of bone loss

CT vs MRI. CT is considered the benchmark for evaluating bone loss in the glenoid and humerus,[10,11] with 3D-CT osseous reconstruction improving the understanding compared to 2D planar imaging. The optimal preoperative imaging modality is the glenoid "en face" view of 3D_CT images.[10,11] Bilateral CT images allow for accurate comparison between shoulders unless the contralateral side is also involved in shoulder instability.

The 3D-MRI, using a 3D isotropic volumetric interpolated breath-hold examination (VIBE) sequence, has been postulated to be equivalent to 3D-CT in evaluating bone loss.[12] This modality has several advantages: the radiation dose associated with CT would no longer be required, and the patient would only be required to undergo one examination, reducing the overall cost of healthcare (Figure 1).

Critical vs subcritical glenoid bone loss. The concept of glenoid "critical bone loss" was established

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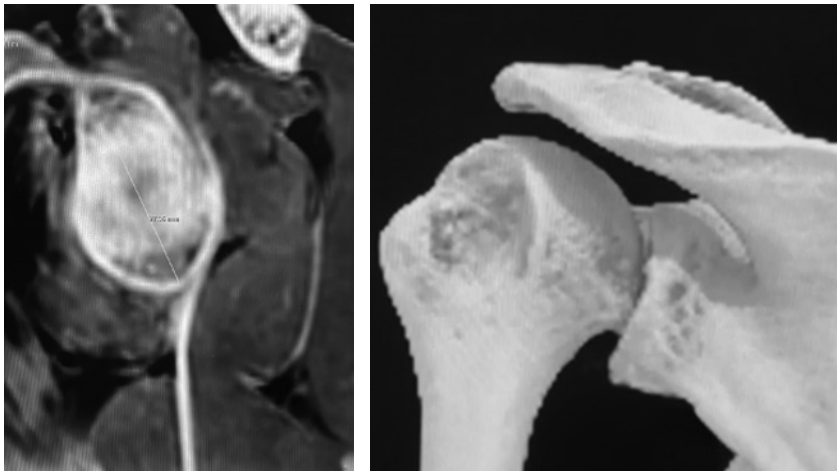

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Fig. 1

MRI volumetric interpolated breath-hold examination sequence showing a) 2D sagittal en face view and b) 3D view.

to set a threshold of a maximum percentage of bone defects accepted for successful soft-tissue repair. Initially, Burkhart and De Beer[13] set this threshold at 25% defect of glenoid width, Itoi et al[14] at 21%, and Sugaya et al[15] at 20%. However, subsequent studies have demonstrated that even smaller bone defects are relevant,[16-19] defining the concept of "subcritical" bone loss. These values have progressively decreased over time, with defects as low as 15% being a risk factor for recurrence of instability and even 13.5% resulting in unacceptable Western Ontario Shoulder Instability Index (WOSI)[20] scores in an actively demanding population.[21,22]

Today, bone loss over 10% in young patients resulting from glenoid erosion has to be considered at risk of failure and reoperation when treated with soft-tissue procedures.[23]

Glenoid measuring techniques. There are multiple measurement techniques for calculating glenoid bone loss. Most are based on either linear or surface area measurements of the best-fit inferior glenoid circle measured on the 3D-CT "en face" view of the glenoid.[15,21,24–26] Other methods attempt to calculate the glenoid bone deficiency based on statistical shape models that provide an equation.[27–29] It is important to note that there is variability depending on the measurement technique used, and their results are not interchangeable.[30,31] Recent studies have demonstrated that surface area measurements of the best-fit inferior circle are the most reliable (Figure 2).[11,32]

When using the 3D-CT en face view, meticulous positioning of the scapula is crucial because slight variations may significantly alter the defect measurement.[33] Also, the drawing of the best-fit inferior glenoid circle has poor interobserver reliability.[34] This method may be improved by adjusting the size and position of the best-fit circle based on the results of anatomical studies.[35]

The glenoid concavity is crucial in determining the joint's stability ratio (SR). This SR is defined as the maximum dislocating force the joint can resist in relation to a medial compression force.[36] For instance, two patients with a 1 mm loss of bone from the glenoid face can experience different levels of instability depending on the depth of the glenoid, with deeper glenoids being more unstable than shallower ones when bone loss is present.

Fig. 2

Bone loss measured using the glenoid defect area method in which the area of the defect (red area) is divided by the area of the full circle (white circle) to achieve a percentage.

Computer finite element studies and cadaveric studies emphasize the importance of including glenoid concavity as a surrogate of the SR, as it can potentially influence clinical decision-making in treating glenohumeral instability.[37,38]

Hill-Sachs lesion and glenoid-track measurement. Hill-Sachs lesions can be assessed using different methods. One method is dynamic examination during arthroscopic surgery, which should be performed after the Bankart repair to determine a true engaging Hill-Sachs lesion.[39] Data suggest that this

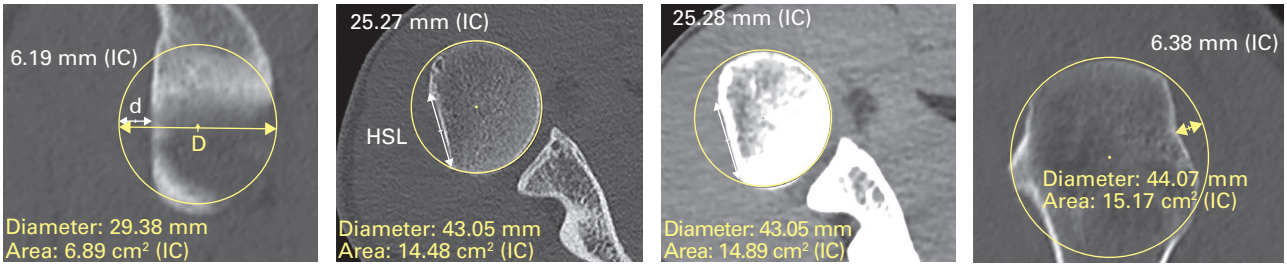

Fig. 3

a) CT showing an off-track lesion. b) Glenoid track (0.83D – d) is smaller than the width of the Hill-Sachs lesion. c) A soft-tissue CT window showing infraspinatus insertion helps in accurately measuring the Hill-Sachs lesion width. d) Sagittal CT view shows the Hill-Sachs lesion depth.

standardized arthroscopic tracking method is superior to conventional radiological tracking.[40]

The other methods are based on 3D-CT reconstructions. The measurement of length, width, and depth of the Hill-Sachs lesion has demonstrated high interobserver reliability,[41] with larger and more medial Hill-Sachs lesions engaging the glenoid earlier. The orientation of the Hill-Sachs lesion might play a role alongside the angle of the humerus at which the lesion becomes engaging, with a higher risk associated with lesions that are more perpendicular to the humeral axis.[42] There is controversy about the arm position where the dislocation occurs, but Kawakami et al[43] suggest that it happens at mid-range of abduction-external rotation when observing the Hill-Sachs lesion position. Conversely, the arm position at which dislocation occurs might differ from the arm position while dislocated.

The "glenoid track" concept is commonly used to assess the risk of engaging the Hill-Sachs lesion relative to the glenoid. This concept involves the contact of the glenoid face on the posterolateral humerus as the arm goes into the abduction and external rotation from 0° to 90°, which can be calculated on a CT exam (Figure 3). The contact glenoid on the humerus corresponds to only 83% of the glenoid, so if the Hill-Sachs lesion crosses the glenoid representation, the injury is considered off-track, and the patient has a higher risk of dislocation.[42,43] However, soft-tissue laxity might play a role in narrowing the glenoid track when the shoulder is hypermobile.

Recently, Yamamoto et al[44] introduced the concept of peripheral-track lesions, which were those on-track lesions with a Hill-Sachs lesion occupancy of > 75%. This injury does not affect the dislocation rate but may negatively influence clinical outcomes. A new measurement known as the distance-to-dislocation value has been introduced. This measurement determines the distance between the Hill-Sachs lesion's medial edge and the glenoid track's medial edge. If the distance-to-dislocation value is less than 8 mm, it can be considered a risk factor for failure after Bankart alone, particularly in patients aged 20 years or older.[45]

Surgical options for glenoid bone loss

Open Latarjet. The original Latarjet procedure was first described by French surgeon Michel Latarjet in 1954.[46] Over time, modifications have been made to the procedure, including changes in the subscapularis split, graft position and fixation, type of fixation, and capsule management.

The standard open technique, as recognized by most surgeons today, was described by Edwards and Walch[47] and involves harvesting the coracoid along with the attached conjoined tendon through a small deltopectoral approach (Figure 4). The inferior surface of the coracoid and the anterior glenoid face are prepared to achieve a flat cancellous bleeding surface via a subscapularis split. Fixation is achieved using two bicortical 4.0 malleolar screws placed at the 4 and 5 o'clock positions, flush with the anterior glenoid surface and below the equator. Additionally, the stump of the coracoacromial ligament is repaired to the capsule with the arm in 30° of external rotation. This technique is an evolution of the triple blocking effect described by Patte et al.[48]

With the appropriate indication and technique, the Latarjet procedure significantly improves patient function and outcome scores, with low rates of recurrent instability (1% to 3%).[49,50] It has also been demonstrated to be reliable in competitive athletes, with a faster recovery and higher return to sport rate than an arthroscopic Bankart repair.[51] After the Latarjet procedure, 88% of athletes return to sport, with 72.6% returning to the prior level of play; and the mean time to return to sport is 5.8 months.[52] However, extensive reviews describe an overall complication rate of 15% with the open Latarjet procedure,[53] including neurological damage, infection, bone block nonunion or fracture, and screw-related problems (Figure 5). Although meticulous surgical technique and a good understanding of the local anatomy can help to avoid complications, postoperative shoulder arthritis and bone block resorption remain unsolved additional challenges.[53–59]

Arthroscopic Latarjet. The arthroscopic Latarjet procedure was pioneered by Laurent Laffose.[60] It has been shown to have comparable outcomes to the open approach and the advantages of reduced pain, faster recovery, and fewer complications.[61] It arose as a technique to replicate the one described by Walch using screw fixation, but alternative fixation methods using cortical buttons and all-suture cerclage fixation have been described and may have advantages.[62,63]

Modifications to the arthroscopic technique have mainly focused on technical aspects of the procedure, such as

Fig. 4

Radiograph showing a left shoulder two months after a classic Latarjet procedure with screw fixation.

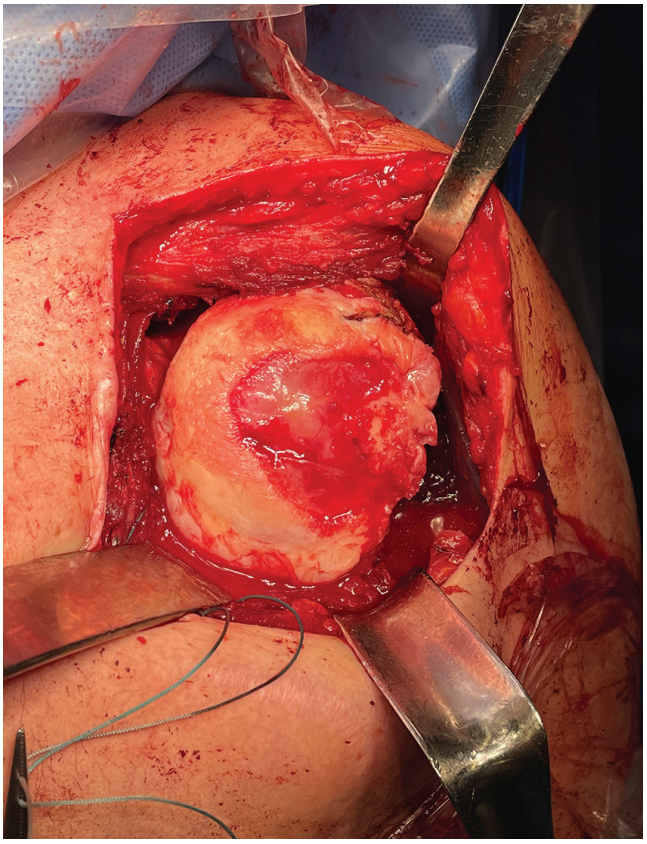

Fig. 5

Intraoperative image showing the humeral head erosion from screw impingement after a Latarjet procedure. This case was revised to a hemiarthroplasty.

performing the subscapularis split and drilling the coracoid to the anterior glenoid. Challenges remain in achieving the correct height of the subscapularis split and protecting the brachial plexus and nerves. The development of new instrumentation including glenoid-aiming guides has facilitated the procedure, but its technical demands and steep learning curve have limited its wider application.[64]

The fixation of the coracoid using all-suture material is safe and effective, and limits the complications observed with screw fixation although it may not decrease the graft's proximal bone resorption rate.[62–66] If it happens, the extra-articular flat softer suture material could reduce the damage on the humeral head when compared to screws. Finally, interconnected double cerclage suture tapes for coracoid graft fixation eliminate the need for buttons, reproduce the compression effect of screws more closely, and control the rotation of the graft.[66]

Free bone block transfer

Eden[67] in 1918 and Hybinette[68] in 1932 were the first to use a free bone block using an autologous tricortical iliac crest bone graft (ICBG) without additional fixation. Several modifications introduced the harvest of bicortical grafts or the use of screws for graft fixation to the anterior glenoid neck.[69] A J-shaped bone graft was popularized in 2008 by Auffarth et al,[70] which involved an implant-free press-fit insertion of the graft in an incomplete osteotomy of the anterior glenoid neck.

The advantages of the use of ICBG are that the donor bone is autologous, it is available, and is not associated with additional cost. The technique is suitable for reconstructing large glenoid defects, but at the cost of high donor-site morbidity,[68,71] and without the sling effect of the Latarjet procedure. Moreover, ICBG does not restore the articular cartilage or the concavity of the surface, which could lead to secondary osteoarthritis.[53] The rate of recurrent instability using ICBG is comparable to the Latarjet procedure.[71–74]

Provencher et al[75] first introduced distal tibial allograft in 2008. They described the use of the lateral aspect of the distal tibia as a fresh osteochondral allograft (Figure 6). Distal tibial allograft has the advantage of restoring the articular cartilage, relative technical ease, and suitability for large glenoid defects. Biomechanical studies have demonstrated that distal tibial allograft allows for improved joint congruity and lower peak forces within the glenohumeral joint compared to the Latarjet procedure.[76]

Obtaining a radius of curvature of distal tibial allograft similar to the recipient glenoid is not easy, with only 22% of randomly paired distal tibiae and glenoids being within 0.3 cm of one another.[77] Further disadvantages of fresh osteochondral

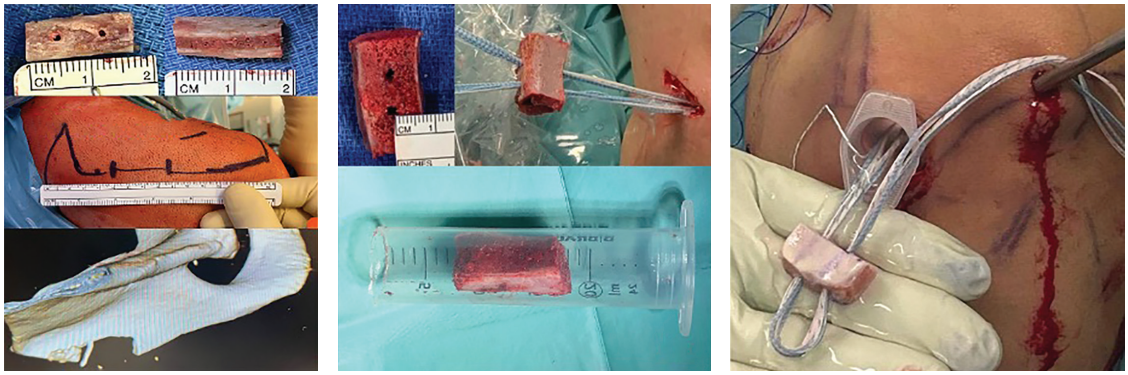

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Fig. 6

Different types of graft that may be used with the bone block procedure fixed with a Fibertape cerclage procedure are shown. a) Scapula spine. b) Iliac crest. c) Distal tibial allograft.

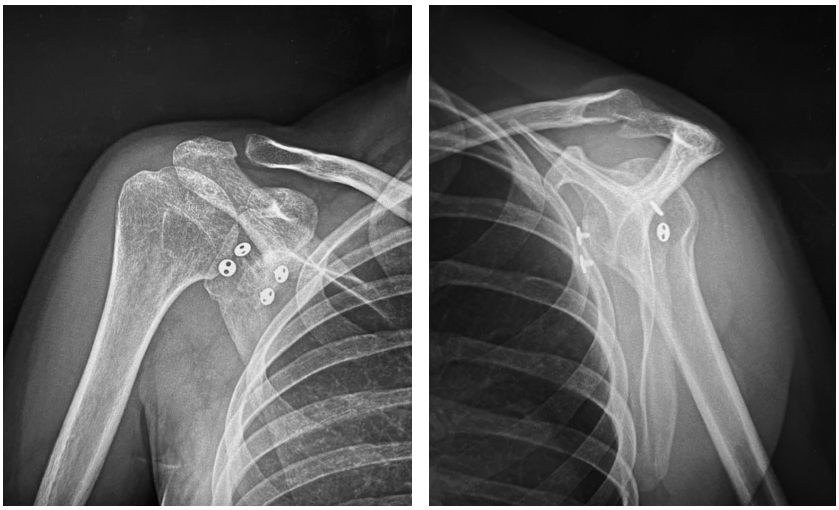

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Fig. 7

a) Anteroposterior and b) sagittal radiograph of a right shoulder showing a bone block procedure with double endobutton fixation.

allografts are the high cost and low availability, with only a two-week window to be implanted in the recipient.[78] Thus, the use of fresh-frozen allografts has become more common but could show a higher rate of graft resorption secondary to immunological response.[79]

In 2014, Tokish et al[80] introduced distal clavicle autograft (DCA) in managing anterior glenoid bone loss. Boileau et al[81] modified this technique by using the undersurface of the clavicle instead of the lateral end.

The DCA has the limitation of only being able to restore medium-sized bone glenoid defects (22% to 30%).[82,83] However, its availability, osteochondral nature, proximity to the glenohumeral joint, low donor-site morbidity, and lack of associated costs make this type of graft attractive. The main drawbacks are that the distal clavicle cartilage may be compromised in cases of acromioclavicular joint arthritis, the theoretical disruption of the acromioclavicular fulcrum leading to scapula dyskinesis, and the lack of clinical series to support its use.

Due to its similar dimensions to the coracoid and iliac crest, autograft from the scapular spine has been considered an appropriate autograft source for glenoid bone augmentation.[84] The advantages of scapular spine autograft include its availability, proximity to the glenohumeral joint, and relative ease of harvest.[85] However, the main disadvantage of a scapular spine graft is that it only seems suitable for reconstructing subcritical bone defects. In one series, only 66% of scapular spine grafts were able to restore a 20% glenoid defect.[82] It is recommended to be harvested at 49.6 mm lateral to the medial scapular border because it provides the largest cross-sectional graft.[84] Furthermore, it does not contain cartilage because it is

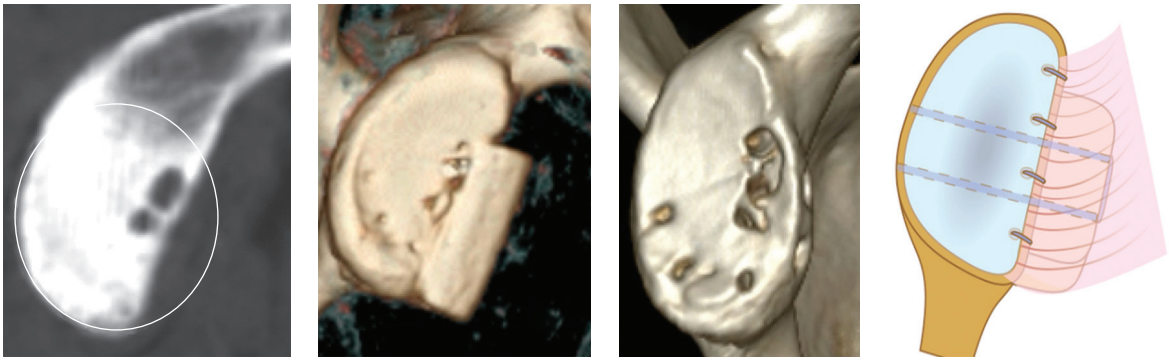

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Fig. 8

a) The preoperative sagittal view of a CT-2D image of a shoulder with anterior instability and a significant bone defect is shown. The best-fit circle is calculated using a circle encompassing the two points tangential to the glenoid's most posterior and inferior border. An "en-face" 3D CT image without the humeral head of a case using a free bone block cerclage. b) Immediate postoperative imaging. c) Result at two years after reconstruction with iliac crest allograft showing global remodeling with the restoration of the glenoid area. d) Illustrative drawing of the bone block cerclage technique to reconstruct the bone defect in anterior shoulder instability with the iliac crest graft and capsule-labrum repair.

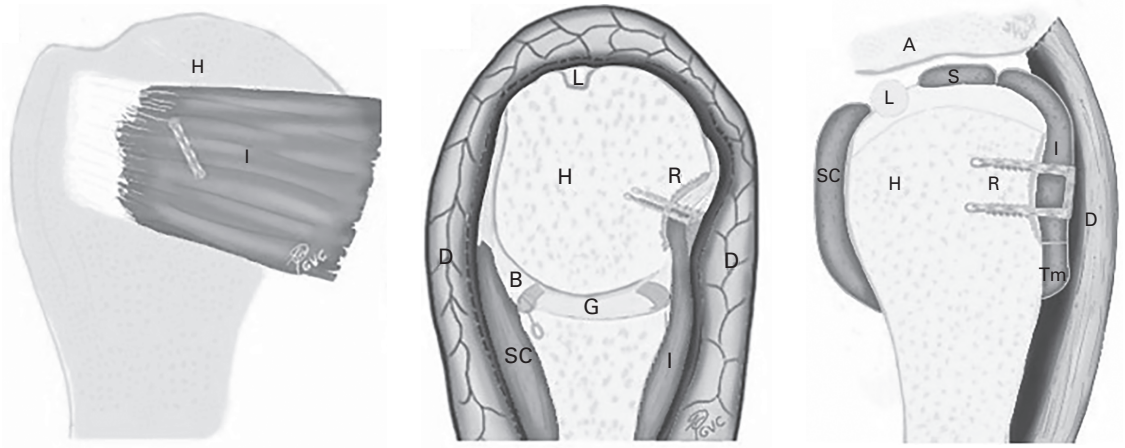

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Fig. 9

a) Coronal, b) axial, and c) sagittal views of arthroscopic remplissage technique with knotless tape bridge for Hill-Sachs lesion. A, acromion; B, Bankart lesion; D, deltoid; G, glenoid; H, humeral head; I, infraspinatus muscle; L, long head of biceps; R, remplissage; S, supraspinatus muscle; SC, subscapularis muscle; Tm, teres minor.

a non-articular graft, and its trapezoidal shape makes this graft difficult to manage.

There is only one study on the outcomes associated with arthroscopic scapular spine autograft.[86] A case series of 27 patients with subcritical (15%) glenoid bone loss were treated using suture anchor fixation and reported excellent Constant-Murley scores,[87] minimal pain, and no redislocations at a mean follow-up of 29 months.

Surgical techniques for free bone block transfer. The open Eden-Hybinette procedure is the oldest free bone block surgical intervention described for treating anterior shoulder instability.[68] Standard practice is to use an ICBG fixed with two 3.5 mm AO screws to the anteroinferior glenoid neck through a complete subscapularis tenotomy.

There are some long-term concerns with this technique: loss of external rotation, a high rate of glenohumeral osteoarthritis, and osteolysis around the screws.[88] This procedure has commonly been used to revise failed Latarjet procedures and is especially useful in cases of greater bone loss where the Latarjet procedure is insufficient.[89] To avoid open surgery and decrease severe neurovascular complications, arthroscopic glenoid reconstruction using a free bone block was developed.[90] These procedures are considered anatomical because they spare the subscapularis contrary to previous techniques including Latarjet.

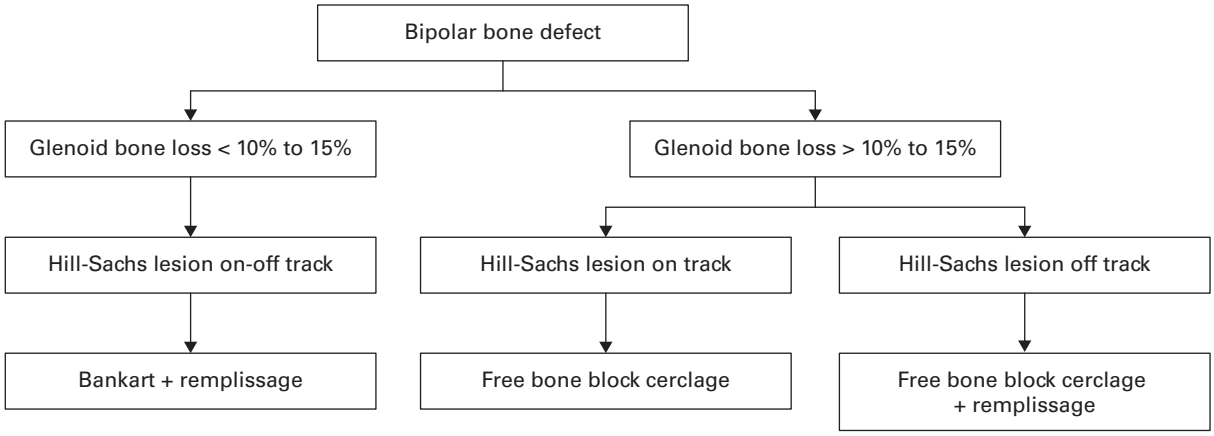

Fig. 10

Treatment algorithm for anterior shoulder instability with bipolar bone loss.

In 2008, the first arthroscopic techniques were introduced using bioabsorbable screws for ICBG graft fixation adding a capsulolabral repair, making the graft extra-articular.[90] Modifications were introduced by Kraus et al[91] using a suture anchor fixation technique, and Taverna et al[92] described a suture button fixation construct to augment the anterior glenoid (Figure 7). Most recently, Hachem et al[93] described a metal-free fixation of ICBG using a suture tape-linked cerclage (Figure 8). This construct may provide additional rotational stability compared to independent buttons and allow strong graft compression to the glenoid neck.[94] Additionally, the two-year outcome study in 23 patients showed excellent results, with only two allograft failures requiring reoperation. Graft resorption affected mostly the lateral unloaded areas of the graft outside the best-fit circle in all cases.[95]

Wong and Urquhart[96] used the advantages of distal tibial allograft for an arthroscopic technique performed in the lateral decubitus using the rotator interval "Halifax" portal. The advantages of this portal include a safe passage of the bone graft and screws placed parallel to the glenoid and perpendicular to the glenoid defect. They reported excellent results using the WOSI, with no redislocations, at a mean follow-up of 4.7 years in a group of 73 patients.

Overall, the arthroscopic free bone block has shown excellent short-term results, regardless of the technique, with a low redislocation rate and a high rate of return to sports even among competitive at-risk athletes.[95,97,98]

Free bone block versus Latarjet. It is controversial which technique is better. Several systematic reviews showed similar clinical outcomes of both techniques.[73,74] One found no significant difference between the two procedures in any studied variables, but highlighted the heterogeneity of outcomes, questioning the conclusions.[72] Moroder et al[71] compared the Latarjet and ICBG procedures in the first ever randomized controlled trial on this topic, and found no difference in clinical and radiological outcomes except for significantly worse internal rotation capacity in the Latarjet group and donor-site sensory disturbances in the ICBG group. These techniques have been developed arthroscopically. While both are demanding, the learning curve of arthroscopic Latarjet is longer, and there is a higher risk of complications, including neurovascular injury and difficulty revising distorted anatomy.[99,100]

Surgical options for humeral bone loss

The remplissage, as described by Wolf and Pollack,[101] involves filling the Hill-Sachs lesion with the infraspinatus and fixing it with bone anchors. This potentially prevents the engagement of the humeral defect and might additionally tension the posterior capsule, which was proved effective as an add-on to an arthroscopic Bankart repair.[102] This technique is safer and more effective compared to an isolated Bankart repair for patients with subcritical bone loss.[103–105] The main concern of this technique is the loss of external rotation.[106]

In recent years the indications for remplissage have expanded because it is fast, technically straightfoward, and seems to be effective in reducing the risk of recurrence.[107] This is especially relevant in athletes, because the return-to-sport rate of arthroscopic Bankart plus remplissage is significantly higher compared to an isolated Bankart repair.[108]

Patients with a Hill-Sachs lesion that extends medial to the peripheral track have worse WOSI outcomes when treated with an isolated Bankart repair.[44] Therefore, it is suggested that they should be considered as an off-track lesion and treated accordingly with an additional remplissage.

Since the first description in 2004,[101] several technical variations have been described, including remplissage with one or two knotted or knotless anchors, double or triple bridging pulleys, and with or without the need for subacromial viewing. Recently, an arthroscopic all-inside remplissage technique with knotless tape bridge has been described to facilitate suture handling and reduce surgical time (Figure 9).[109]

Osseous allografts for anatomical reconstruction have been proposed in young patients with large humeral defects as a useful strategy to avoid the use of a prosthesis. Techniques with fresh-frozen humeral head allografts and femoral head allografts have been described successfully.[110,111] Other sources of grafts, including the talus, have been described.[112]

An alternative technique for young patients with humeral bone loss > 40% is the HemiCAP partial resurfacing (Arthrosurface, USA).[113] This is a spherical cobalt-chrome component impacted in the Hill-Sachs lesion to fill the defect and restore joint congruity. Due to implant instability, it is contraindicated in patients with osteoporotic bone. Raiss et al[114] performed this technique in ten patients with locked anterior dislocation and significant humeral bone loss, and found an increased Constant-Murley score of 41 points postoperatively with two reoperations.

Shoulder hemiarthroplasty is reserved for low-demand or elderly patients with osteoporotic bone and defects larger than 40% of the humeral head. A total shoulder arthroplasty might be considered in those patients with concomitant glenoid wear.

Surgical options for bipolar bone loss

Bipolar bone loss is a well-recognized risk factor for failure of isolated Bankart repair, but there are no clear guidelines regarding surgical management for this entity. Although initial cadaveric studies suggested setting the glenoid bone loss threshold at 20% to 25%, evidence of worse results in subcritical bone loss mean that current thresholds are around 15%.[8]

As previously mentioned, all patients with minor or subcritical bone loss and off-track or peripheral-track Hill-Sachs lesion are at greater risk after an isolated Bankart repair. Experimentally, it has been shown that Bankart repair does not restore normal kinematics and stability of the shoulder in the presence of glenoid bone loss greater than 15%.[16] Additional surgical measures can limit this risk, in most cases remplissage. Other potential measures to augment the capsulelabral repair have been described as a "Bankart-plus" procedure,[115] which adds demineralized spongy bone matrix, or the subscapularis augmentation.[116]

Above the critical glenoid bone loss threshold (20%) associated with off-track Hill-Sachs lesion, the Latarjet or bone block procedures have been classically accepted as the gold standard.[17] New studies challenge this concept, demonstrating that remplissage and Latarjet provided similar outcomes for patients with > 15% glenoid bone loss and off-track Hill-Sachs lesion, with only remplissage patients having slightly decreased external rotation.[107]

Surgical decision-making

Our practice is to perform remplissage with every Bankart repair in patients with glenoid bone loss < 10% to 15% and a Hill-Sachs lesion based on the most recent evidence (Figure 10).[108] The remplissage not only provides a further structural support to avoid dislocation, but we believe it also contributes to improving apprehension by reducing the size of Hill-Sachs lesion, and limiting the anterior translation of the humeral head.

We tend to manage glenoid bone loss > 10 to 15% with an off-track Hill-Sachs lesion with bone augmentation procedures, especially in active or hypermobile patients.

Conclusion and future directions

Bone defects are frequently observed in anterior instability. Imaging studies, especially 3D-CT reconstructions, can provide an objective preoperative analysis of the location and size of the defect. The 3D-MRI using a 3D isotropic VIBE sequence has emerged as an equivalent image modality avoiding radiation to the patient.

On the glenoid side, it is uncontroversial to consider the threshold for a critical glenoid defect as being 20%. However, poor outcomes have been described even with a subcritical glenoid bone defect as low as 13.5%. Other anatomical factors, such as glenoid concavity, could influence the risk of recurrence. On the humeral side, the Hill-Sachs lesion should be evaluated concomitantly with the glenoid defect as the two sides of the same bipolar lesion which interact in the instability process as described by the glenoid track concept. A recent survey among North American surgeons revealed that there is a consensus on the management of cases with no humeral bone loss and isolated glenoid critical bone loss with respective soft-tissue and bone block management, but there is not yet consensus when isolated critical humeral bone loss and bipolar bone loss are present.[117]

Our treatment algorithm finds no evidence-based reason not to add remplissage to every Bankart repair in patients with a Hill-Sachs lesion, regardless of the glenoid bone loss. When critical or subcritical glenoid bone loss occurs in active patients (> 15%) or bipolar off-track lesions, we should consider anterior glenoid bone reconstructions.

New arthroscopic techniques of glenoid bone reconstruction have been developed, which allow precise positioning of the graft, identification, and treatment of concomitant injuries with low morbidity and faster recovery. Given the problems associated with bone resorption and metal hardware protrusion,[58,59] the new metal-free techniques for Latarjet or bone block procedures seem a good solution to avoid these complications, although no long-term data are yet available.

Take home message

- The Hill-Sachs lesion and glenoid defect should be evaluated as the two sides of the same bipolar lesion.
- The Remplissage procedure is strongly recommended associated to Bankart repair in patients with a Hill-Sachs lesion, regardless of glenoid bone loss.
- Bone block procedures involving the coracoid or free bone grafting are recommended for treating glenoid bone loss.
- Metal-free techniques are a good solution to avoid hardware-related complications.

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