Current Trends in Management of Glenoid Bone Loss in Anterior Shoulder Instability

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Abstract

Significant bone defects of glenohumeral joint play an important role in the management of shoulder instability. Bony instability is an important cause of failed soft-tissue repair and recurrent episodes of shoulder dislocations. Bony instability can also be associated with labral (superior and posterior) tears, humeral avulsion of glenohumeral ligament lesions, or rotator cuff tears. Computed tomography (CT) scan with three-dimensional reconstruction is essential for quantification of glenohumeral bone loss. Magnetic resonance imaging (MRI) is reliable for quantification of bone loss, and in addition, demonstrates the soft tissue pathology. Surface area based methods of quantifying glenoid bone loss are more accurate than width based methods. Certain factors important in managing patients with anterior glenohumeral instability include patients' age, level of sports participation, involvement with contact sports, time of presentation (acute or chronic), and type of bony defect (bony Bankart or attritional bone loss). Soft-tissue reconstruction procedures (labroplasty and remplissage) are usually used in managing patients with nonsignificant bone loss. Patients having significant bone defects of glenoid (>25%) and humerus (off-track/engaging Hill-Sachs lesions) are candidates for open bone grafting of glenohumeral bone defects. Coracoid transfer(Latarjet procedure), either mini-open or arthroscopic gives good functional results and decreases chances of recurrence. Associated lesions should be addressed concomitantly to improve the functional outcome in patients with bony instability of the shoulder. This review presents an evidence-based comprehensive diagnostic and treatment options for patients with bony glenoid deficiency in anterior shoulder instability.

Keywords: Shoulder instability, Hill-Sachs lesion,Labroplasty, Latarjet procedure,Remplissage, Glenoid bone loss, Bony Bankart.

Introduction

Significant bone defects of glenohumeral joint play an important role in the management of shoulder instability. Burkhart and DeBeer [1] first reported a recurrence rate of 67% in patients with significant bone defects (89% recurrence rate in contact athletes), and only 4% recurrence rate in patients without significant bone defects. Thereafter, several studies have highlighted the importance of assessing and addressing bone defects in the management of shoulder instability. Approximately, 2% of the general population is affected by shoulder dislocations; of which 95-98% are anterior dislocations [2]. Isolated bony glenoid defects are present in 22% of patients with first-time anterior dislocation compared to 73% with chronic recurrent anterior shoulder instability [3]. Associated bony fragment (bony Bankart lesion) may be seen in 5-55% of cases with the first episode of anterior shoulder dislocation [4]. Humeral bone loss is present in approximately 40-90% of cases of initial anterior glenohumeral dislocations, and in 70-100% in recurrent anterior glenohumeral instability [5,6]. Bony instability associated with other lesions (superior and posterior labral tears, humeral avulsion of glenohumeral ligament [HAGL], rotator cuff tears) are common in contact sport players (rugby players) [7] and need to be addressed concomitantly [8,9].

Diagnosis

Bony instability may be suspected clinically; Bushnell et al. [10] have described "warning signs" on history and clinical examination, and these may be used for screening patients with anterior shoulder instability. These signs include frequent and easy dislocations (sleep episodes, dislocation in lesser degrees of abduction and external rotation), history of initial high energy trauma, and previous failed surgery for stabilization. Bushnell et al. [11] also described bony apprehension test (apprehension at 45°of abduction and external rotation) to clinically identify the patients having significant glenoid and humeral bone loss.

Imaging Techniques

Imaging helps in both identification and quantification of the amount of bone loss in patients with anterior shoulder instability. Although the glenoid bone loss is not always evident on radiographs, initial imaging workup for patients includes anteroposterior and axillary views of the shoulder. Special

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Table 1: Radiographic views to identify bone loss in anterior shoulder instability

Radiographic views	Description	Remarks
Glenoid Views		
Garshney AP view [12]	Anteroposterior view of the shoulder taken in the plane of scapula	Good visualization of glenohumeral joint space
West Point Axillary [13]	Patient prone with involved shoulder abducted to 90 degrees and the shoulder raised 8 cm on padding and X ray beam targeted on ipsilateral axilla with 25 degrees on medial and downward angulation	Good view of anteroinferior glenoid as the beam is tangential to it. Can detect bony lesions of anteroinferior glenoid.
Apical Oblique [14]	Patient stands with 45 degrees posterior oblique position to the X ray plate and beam directed 45 degrees caudad centered on shoulder.	Effective in identification of anteroinferior glenoid rim fractures
Bernageau [12,16]	Medial to lateral X ray beam in plane of scapula with 30 degrees of inferior angulation and ipsilateral hand touching the contralateral suprascapular area over the head.	Identify glenoid bone loss,valid and reliable to quantify bone loss
Modified Bernageau [19]	X ray taken with patient in TV watching position	Technically easy to obtain and good delineation of glenoid bone loss
Humeral Head Views		
AP Shoulder in Internal Rotation [12,14]	Anteroposterior view of shoulder with shoulder in full internal rotation	Visualization of humeral head and also profile view of lesser tuberosity
Stryker Notch [12,14]	Supine patient with affected side hand behind the back of head and X ray beam directed 10 degrees cephalad	Evaluate for hill sachs lesion
Ito Technique [20]	Patient supine with shoulder in 135 degrees of flexion and 15 degrees of internal rotation	Clear visualization of the posterolateral humeral head
Coracoid Views		
Bhatia views [21,22]	Superior pillar view (SPV): scapula in 30 degrees posterior angulation and beam directed 30 – 40 degrees cephalad and 20 – 30 degrees of lateral angulation. Inferior pillar view (IPV) : radiographic beam 20 – 30 degrees medial angulation and 30 – 40 degrees cephalad	Visualization of entire superior and inferior pillars of coracoid. Useful in pre-operative planning for dimensions of coracoid prior to harvest. Clear delineation of coracoid fractures and their extension into the surrounding region.
True Axillary view [13]	True lateral view of shoulder taken with the arm in abduction	Allows identification of humeral head compression fractures, coracoid process and also the glenoid rim lesions or wear
Goldberg view (23)	Patient positioned 20 degrees posterior oblique to the X ray film with beam directed in 20 degrees cephalad angulation centered on coracoid	Demonstrate coracoid fractures when not seen on other views

projections may be used to (a) identify glenoid bone loss, (b) identify humeral bone loss, and (c) to assess the coracoid process before a surgical coracoid grafting procedure (Table 1).

Glenoid specific radiographs include the True (Garshney) AP [12], West Point axillary [13], apical oblique [14], Dindee [15], and Bernageau views [12,16]. True AP and Bernageau views are 66% sensitive and 100% specific to identify glenoid bone lesions [17]. The apical oblique view [14] is effective for identification of the antero-inferior glenoid rim fractures. Furthermore, West point view is particularly useful for detection of the bony Bankart lesions, as the rays are tangential to the antero-inferior glenoid [18]. Sugaya [19] described a modified Bernageau view with the patient positioned on the table instead of the standing position (TV watching view). This view is relatively easier to obtain and helps in better identification of glenoid bony pathology.

Plain radiographic views that are sensitive for identification of humeral head bone defects include anteroposterior view with shoulder in maximum internal rotation and the Stryker-Notch view [12,14]. These views do not exactly quantify amount of bone loss and hence should be supplemented with more precise imaging. The Ito technique [20] clearly demonstrates the posterolateral humeral notch: the patient is supine with the arm in 135°of flexion and 15°of internal rotation and the cassette directly under the shoulder joint. The central X-ray beam is angled vertically through the humeral head.

Radiographs can also be used for pre-operative assessment of coracoid process before performing a Latarjet procedure. Bhatia et al. have described the clinical anatomy of coracoids [21] and have suggested the use of orthogonal coracoid

Table 2: Surgical procedures used by one of the authors (DNB) to treat bony instability in athletes

Surgical techniques	Description
Arthroscopic Labroplasty [52]	Sequential tensioning of the capsulolabral complex to recreate a labral bump at the anterior glenoid rim.
Arthroscopic All-inside "Double-barrell Remplissage"[57,58]	Attachment of infraspinatus and posterior capsule into the Hill-Sachs defect, uses a novel double-barrell knot for tensioning the infraspinatus.
Mini-open Latarjet procedure[62]	Coracoid process transfer along with the conjoint tendon to the anterior glenoid rim using a mini-open subscapularis split approach
Mini-open congruent arc Latarjet procedure [1, 66, 67]	Coracoid process transfer along with the conjoint tendon to the anterior glenoid rim using a mini-open subscapularis split approach. The coracoid block is "flipped" to orient the inferior coracoid surface along the articular glenoid surface, and a capsular shift is added.
Dual-window subscapularis-sparing approach for combined coracoid transfer and HAGL repair[70]	Lateral subscapularis-sparing window is used for HAGL repair, and medial split is used for a congruent -arc Latarjet procedure.
Arthroscopic Latarjet[71]	Coracoid process transfer along with the conjoint tendon to the anterior glenoid rim using an arthroscopic approach
Arthroscopic Latarjet and Capsular Shift (ALCS procedure)[72]	Coracoid process transfer along with the conjoint tendon to the anterior glenoid rim and capsular shift using an arthroscopic approach
Arthroscopic/ open bone grafting[73, 74, 75]	Bone grafting procedure using autograft iliac bone

views (superior pillar view, and inferior pillar view) for visualizing individual coracoid pillars [22]. The orthogonal views do not require abduction of arm or shoulder movement and hence makes them useful in acute setting, and chronic cases with severe apprehension. Other coracoid views include the Goldberg view [23] and axillary lateral views (Table 1).

CT scan with three-dimensional (3D) reconstruction is considered the gold standard in diagnosis and quantification of the glenoid and humeral bone loss [24,25]. Saito et al. [26] in their CT-based study reported that Hill-Sachs lesions exist approximately at a distance of 0-24 mm from the top of the humeral head in the posterosuperior portion. Miniaci and Gish [27] recommended the use of 3D CT scans over two-dimensional (2D) scans to identify the orientation of the humeral head bone loss; they suggested that humeral head defects are often oblique to axial plane and are not well appreciated on 2D CT image. Lee et al. [28] evaluated the effectiveness of MRI for assessment of glenoid bone loss. They concluded that glenoid bone loss determined on en-face glenoid view of high-spatial-resolution MRI (Fig. 1) is comparable to CT scan. MRI also helps in identification of associated soft tissue pathology (rotator cuff tears, Superior labrum anterior to posterior (SLAP) tears, HAGL lesions). For identification of Hill-Sachs lesion, MRI is highly sensitive but has high chances of false positive results. MR arthrography has been recently tested in evaluating patients with anteroinferior instability with bone loss [29]; it does not have any practical application in acute setting [30]. However, in chronic setting, it is comparable to 2D and 3D CT scan in identifying patients with significant bone loss in anterior shoulder instability. Although results are comparable, certain factors limit its applicability, like higher costs, need for injection of dye into joint and its associated complications (allergic reactions, infection).

Ultrasonography can also be used for delineation of bone defects in patients with glenohumeral instability, but the results are operator dependent and do not give an idea about the true location and orientation of the defects [31].

Significant Bone Loss

The amount of anteroinferior glenoid bone loss beyond which there is an increased risk of recurrent anterior shoulder instability or

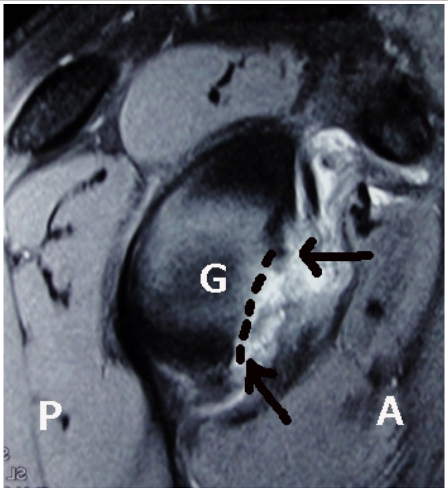

Figure 1: Magnetic resonance imaging(MRI) image showing glenoid defect and labral tear:A sagittal MRI image of the glenoid (G) shows the glenoid defect (dotted line), and the extent of labral tear is demonstrated (arrows) (A: Anterior, P: Posterior).

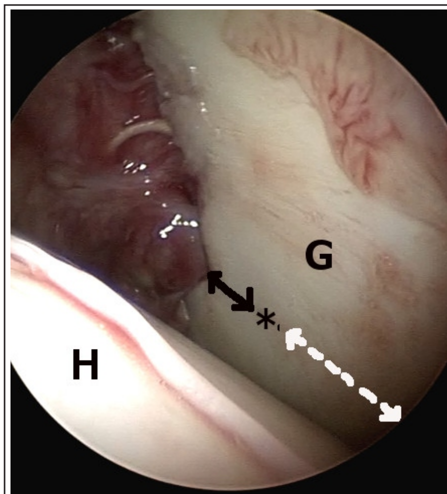

Figure 2: Significant glenoid bone loss: Arthroscopic image shows an "inverted-pear" appearance of the glenoid(G). The bare spot (asterix*) is used for measuring anterior width (black arrow) and posterior width (white arrow) (H: Humeral head).

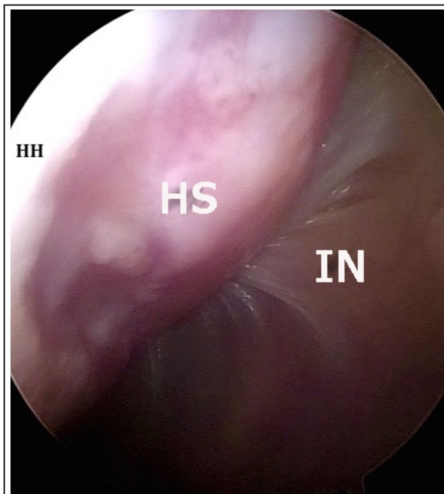

Figure 3: Significant humeral bone loss:Arthroscopic image showing humeral head(HH) with infraspinatus posteriorly(IN). Significant Hill Sachs lesion(HS) is seen between HH cartilage and attached IN.

a high risk of failure of a labral repair surgery is considered a significant glenoid bone loss. Bigliani et al. [32] considered a 25% reduction in glenoid width as significant bone loss. Itoi et al. [33] showed that glenoid defect width (average defect width 6.8mm) which is 21% or more than the glenoid length is a significant bone defect. Lo et al. [34] first described an inverted pear-shaped appearance of glenoid on arthroscopy as a significant bone loss in patients with anterior shoulder instability (Fig. 2). According to them, these patients had average anterior glenoid width loss of 8.6mm of bone corresponding with 36% of the total width lost. Burkhart and De Beer [1], considered 25% or greater loss of anteroinferior glenoid bone and/or engaging Hill-Sach's lesion as significant. Greis et al. [35] reported that with glenoid bone loss of more than 30%, there is significant increase in the glenohumeral contact pressures making this amount of bone loss biomechanically significant. Flatow et al. [36] described humeral bone defects involving more than 40% of humeral head as clinically significant (Fig. 3). Yamamoto et al. introduced the glenoid track (GT) concept [37]; they suggested that the location and orientation of humeral defect were as important as the size, and therefore were clinically and prognostically significant.

Quantification of Glenoid Bone Loss

Radiological and arthroscopic methods have been described for the quantification of glenoid bone loss. Murachovsky et al. [17] have shown that glenoid defect measurement on the Bernageau view is accurate, reproducible and is comparable to 3D CT scan. Others consider the use of CT scan image more accurate for glenoid bone defect quantification. Huysmans et al. [38] described true circular shape of the inferior two-thirds of glenoid; the approximate center of this circle lies on bare spot in inferior two third of glenoid. Bare spot is present on glenoid where there is thinning of overlying cartilaginous cover and also the presence of increased subchondral density overlying the tubercle of Assaki. The bare spot is used as landmark for quantification of glenoid bone loss in various quantification methods. These methods either make use of glenoid width/diameter or surface area to quantify glenoid bone defects (Fig. 4). Bhatia et al. [39] recently showed that width/diameter based methods are inaccurate in quantifying glenoid bone loss; they suggested that geometric (surface area) glenoid bone loss quantification methods are more precise and such geometric quantification is difficult to be achieved arthroscopically. Sugaya et al. [19] proposed a 3D CT scan based method to quantify glenoid defect as percentage of area lost, of the best fit circle on inferior 2/3 of glenoid with the center at bare area of glenoid. Griffith et al. [25] proposed a CT image based method to identify moderate to severe glenoid bone loss; they used a sagittal oblique en face image of glenoid on multiplanar CT image to measure maximum width of affected glenoid and compared the same with the contralateral normal side. Baudi et al. [40] proposed PICO method to identify glenoid bone loss. In this method, they used CT-based multiplanar reconstruction to calculate the surface area of glenoid. The best fit circle which matches the glenoid of normal side is chosen and superimposed on the affected side. Area of defect is calculated and is expressed as percentage of the best fit circle. Dumont et al. [41] described an easier method to calculate the glenoid bone defect using glenoid arc angle. Glenoid arc angle (α) is the angle subtended on center of inferior 2/3 of glenoid (bare area) and its value is used in a mathematical equation (glenoid bone loss percentage = $[(\alpha - \sin\alpha)/2\pi] \times 100$) to calculate area of glenoid bone loss. Arthroscopic methods for quantification of glenoid bone loss provide direct evidence of bone loss (Fig. 5). Burkhart et al. [42] calculated glenoid bone loss by measuring the distance from glenoid bare spot to the anterior and posterior rim; the difference between the two was expressed as percentage of twice the distance between the glenoid bare spot and posterior rim. Detterline et al. [43] tested the arthroscopic Secant Chord method for quantification of glenoid bone loss. They proved that their method was more accurate than the arthroscopic method of Burkhart et al., however, this method involved additional

Figure 4: Circle method for measurement of bone loss: A sagittal section of the glenoid (G) is used to draw a best-fit circle along the inferior glenoid. The width of the glenoid is subtracted from the diameter of the circle to determine amount of bone loss. Alternately, the area of the circle without bone is measured to determine the area of bone loss.

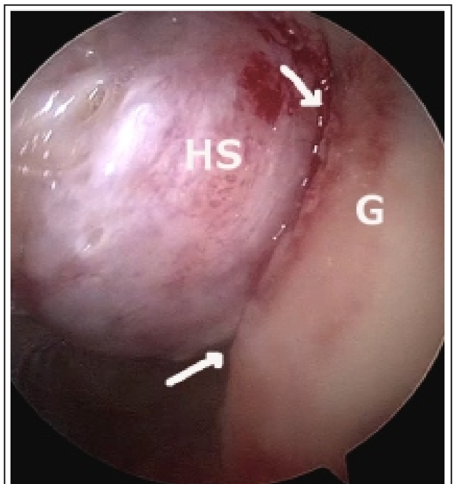

Figure 5: Engaging Hill-Sachs lesion: Arthroscopic image shows dynamic air arthroscopy in abduction and external rotation. The large humeral defect engages the deficient anterior glenoid rim (G: Glenoid, HS: Hill Sachs lesion). Arrows show the engaged humeral head along anterior glenoid margin.

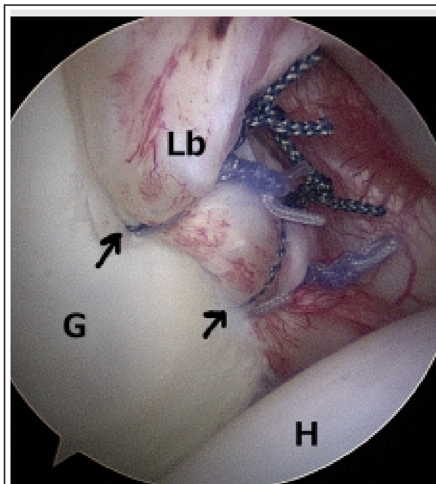

Figure 6: Labroplasty: Arthroscopic image shows a sequential capsular shift using multiple anchors (arrows). The shift creates a new labrum (Lb) at the anterior glenoid rim (G: Glenoid, H: Humeral head).

mathematical calculations. Bakshi et al. [44] recently showed that arthroscopic methods of glenoid bone loss quantification tend to overestimate glenoid bone loss, and thus their validity is questionable.

Quantification of Humeral Bone Loss

Older methods quantified humeral bone loss based on plain radiographs; they expressed the defect as percentage of involvement of 180° arc of humeral head. Rowe et al. [45] proposed depth and length measurement method to quantify humeral head lesions. Based on this, they graded the lesions as mild (<0.5cm deep and <2cm long), moderate (0.5-1cm deep and 2-4cm long), and severe (>1cm deep and >4cm long). Flatow et al. [36] gave a quantitative classification based on the quantification of humeral head defect size as percentage of humeral head (<20%, 20-40% and >40%). They considered lesions >40% size as clinically significant. Montgomery et al. [46] stressed on calculating the defect size on axial and coronal CT images, and the defect size was expressed a percentage of the total area of the humeral head. Yamamoto et al. [37] introduced the GT concept and stressed on understanding the orientation of the humeral bone defect. The orientation of the Hill-Sachs defect and its extent relative to the GT can be known from the 3D CT scan image. They devised mathematical formulae for predicting humeral head engagement in patients with glenohumeral bone loss. Hardy [47] took into consideration depth and volume of the humeral head defect for quantification. They inferred that humeral defects with depth more than 16% of the humeral head volume or volume more than 1000 mm3 are significant.

Associated Pathology

Arrigoni et al. [8] stressed on importance of performing arthroscopy before open Latarjet procedure in patients with significant glenoid bone loss; they found that two-thirds of patients have associated pathologies like SLAP tears, rotator cuff tears or other lesions. These associated lesions tend to be more common in contact athletes (rugby players) [7]. Bhatia and DasGupta [9] showed the presence of HAGL lesions in approximately 1/10 of the patients with significant glenoid bony instability. Forsythe et al. [48] have enumerated importance of identification and treatment of co-pathologies in patients with anterior shoulder instability; they suggested that failure to identify and treat these lesions was an important reason for chronic residual symptoms of pain and instability.

Decision-making Algorithms

Clinical and radiological factors important in managing patients with anterior glenohumeral instability include patients age, level of sports participation, involvement with contact sports, time of presentation (acute or chronic), and type of bony defect (bony Bankart or attritional bone loss). Balg and Boileau [49] developed a 10-point instability severity index score, including 6 prognostic factors which can identify patients who can experience a recurrence of anterior glenohumeral instability preoperatively. These include age at surgery, degree of sports participation, type of sport, shoulder hyperlaxity, Hill-Sachs lesion on anteroposterior radiograph and loss of glenoid contour on anteroposterior radiograph. They found that patients with a score of >6 had 70% recurrence of glenohumeral instability with arthroscopic repair. They recommended management of these patients using open surgical procedure with bone grafting of anterior glenoid defect.

Recent criteria used to evaluate the need for bony augmentation for the glenoid or humeral bone loss in patients with anterior shoulder instability is based on the GT concept. This concept was first introduced by Yamamoto et al. [37]. They studied the dynamic interaction between glenoid and humeral head during abduction and external rotation. They observed that as the limb was abducted and externally rotated; the contact area of glenoid with posterior humeral head shifted from an inferomedial to the superolateral region, and this zone of contact was termed GT. Bony integrity of

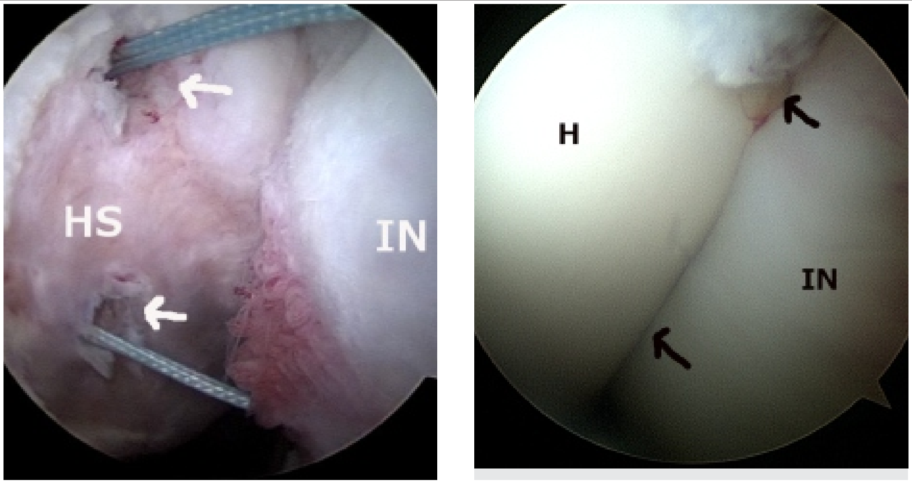

Figure 7: Arthroscopic all-inside double-barrel remplissage procedure. (a) Two single or double loaded suture anchors (arrows) are passed trans-tendon into the humeral defect (HS) to create a large tendon bridge (IN). (b) The humeral defect (arrows) is completely filled by the infraspinatus (IN) after the double-barrel knot is tied.

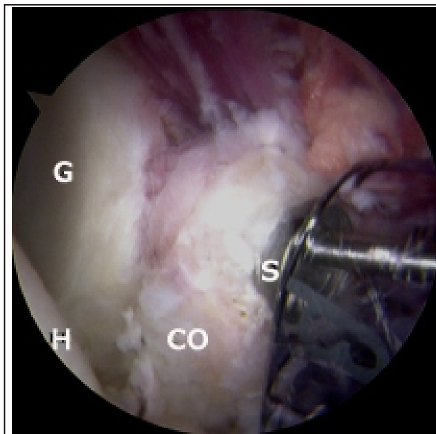

Figure 8: Arthroscopic Latarjet procedure: Arthroscopic image showing glenoid(G), humeral head(HH), and attached coracoid(C) graft on anterior glenoid margin with screw(S). Attached coracoid increases glenoid arc and reduces chances of recurrent humeral head dislocation in patients with significant glenoid bone defects.

GT is essential to maintain stability of shoulder joint in position of abduction and external rotation. Using the concept of GT, Di Giacomo et al. [50] devised formulae to determine whether humeral defect is on track or off track with glenoid. Yamamoto and Itoi [51] inferred that in patients with significant glenoid bone loss (>25%); if the Hill-Sachs index (HSI) is greater than the GT, then the humeral lesion is "off track" and has more chances of engagement after isolated glenoid reconstruction. Such patients are candidates for bone grafting of glenoid using Latarjet procedure. If the humeral defect remains off-track even after the Latarjet procedure, then bone grafting is also indicated for Hill-Sachs defect. If HSI is less than GT in patients with significant glenoid bone defects, then lesion is "on-track" and instability can be managed with isolated bone grafting of the glenoid bone defect. Patients with nonsignificant glenoid bone defects can be managed with arthroscopic soft tissue repair without bone grafting of the anterior glenoid.

Surgical Techniques

Surgical techniques used for treating anteroinferior shoulder instability associated with significant bone defects may be either soft tissue or bony procedures (Table 2). Soft tissue procedures are usually used in managing patients with nonsignificant bone loss. The surgical option in such patients is arthroscopic "labroplasty" (Fig. 6) and is usually combined with a "remplissage" procedure (Fig. 7a and 7b). The labroplasty procedure involves a sequential shift of the capsular tissue in a north-south direction; suture anchors placed in bone are used to securely attach the resultant neo-labum to the glenoid rim [52]. The remplissage procedure involves a tenodesis/capsulodesis of the infraspinatus into the humeral defect using anchors [53]. Biomechanical and clinical studies [54, 55, 56] suggest a definitive advantage if a remplissage is performed in addition to a labral repair. An all-inside arthroscopic remplissage (double-barrel remplissage) recently described using a new "Double-Barrel knot" [57] for attaching the infraspinatus to the Hill-Sachs defect [58].

Bony procedures for management of significant glenoid bone defects can be performed either using open or arthroscopic methods. Bone graft options for open surgery include ipsilateral coracoid autograft, iliac crest autograft, or distal tibial allograft. The Bristow procedure [59] involves transfer of the distal coracoid tip with conjoint tendon on the glenoid defect, through a split in subscapularis. This creates a dynamic buttress along the anterior glenoid and improves the stability of the shoulder joint in abduction and external rotation. Long follow-up [60] of patients operated with the Bristow procedure approximately showed a success rate of 70% and failure rate of about 15%. Late development of glenohumeral arthritis was the major complication. Helfet originally described performing this procedure as an open surgery. Boileau et al. [61] described technique for arthroscopic Bristow procedure. They reported recurrent instability in 8% of patients treated with arthroscopic technique.

The Latarjet procedure [62] was described for the treatment of significant glenoid bone defects using ipsilateral coracoid autograft. Different modifications have been described for original Latarjet technique, and differ in the orientation of coracoid placement on the glenoid face. The Latarjet technique uses 2-3 cm of the coracoid for reconstruction, and the coracoid is fixed along its length to the glenoid defect using two screws. Allain et al. [63] reviewed the results of Latarjet procedure and reported good to excellent results in 88% of patients. None of the patients managed in their series had an episode of dislocation but 12% of the patients had residual instability. There was a substantial loss of external rotation of shoulder compared to normal side, and 62% patients developed glenohumeral arthritis at follow-up. They correlated development of glenohumeral arthritis with far lateral placement of graft, i.e., overhanging the face of native glenoid, and also with the concomitant presence of rotator cuff tears. Mizuno et al. [64] recently published long-term (≥25 years) results of the Latarjet procedure. They reported excellent long-term outcomes for the Latarjet procedure. In their series, though arthritis developed in 23.5% of patients in follow period, the majority had mild grade of arthritis. Patte and Debeyre [65] pointed out the importance of placing the coracoid graft flush with the face of the glenoid to avoid development of glenohumeral arthritis. They proposed suturing of the anterior joint capsule to stump of coracoacromial ligament to achieve the same. Burkhart and DeBeer [1,66,67] described the congruent-arc modification of Latarjet procedure. They used the inferior surface of coracoid to match the face of the glenoid cavity and suggested a similarity between the radius of curvature of the glenoid and the inferior surface of the coracoid. They found a 4.9% recurrence rate at mean follow-up of 59 months in patients of anterior shoulder instability with significant glenoid bone defects treated using this surgical technique. Noonan et al. [68] showed that this modification better restored the coronal radius of curvature of glenoid compared to traditional Latarjet procedure. Ghodadra et al. [69] proved that glenohumeral contact pressures were restored to normal with the use of congruent arc modification. Recently, Bhatia et al[70] described a dual-window subscapularis-sparing approach to repair HAGL lesion and to perform a simultaneous congruent-arc Latarjet procedure. Lafosse et al. [71] developed and described the all-arthroscopic Latarjet procedure to manage patients with significant glenoid bone loss or in patients with associated HAGL lesion (Fig. 8). Bhatia DN [72] described a simultaneous capsular shift technique with the arthroscopic Laterjet procedure [Arthroscopic Latarjet and Capsular Shift procedure (ALCS procedure)] .

The Eden-Hybbinette procedure involves an iliac crest autograft secured with two screws to reconstruct the glenoid defect. The radius of curvature of the inner table of iliac crest matches that of glenoid; this helps in anatomical reconstruction of the glenoid defect and decreases glenohumeral contact pressures [73]. Alvik's glenoidoplasty described by Niskanen et al. [74] is a technique of iliac crest bone grafting without the use of hardware; the iliac crest autograft is fashioned and is press-fixed to glenoid defect. "J bonegraft" technique of Auffarth et al. [75] uses tricortical "J" fashioned iliac crest bone graft for management of glenoid rim fractures in patients with anterior shoulder instability. Author reported good results at long-term follow-up with mild to moderate arthropathy developing in some patients.

Various allograft options have also been evaluated to deal with the large glenoid bone defects especially in the revision scenarios or with defects >30% bone loss. Osteochondral allograft options tested include iliac crest, femur head, glenoid, and distal tibial plafond. Noonan et al. [68] showed that iliac crest and tibial plafond allografts better match the axial radius of curvature of glenoid and restore depth of the glenoid enhancing the concavity compression mechanism and thus the mid-range stability of the shoulder joint. Lateral part of the distal tibial plafond osteochondral allograft most closely matches the glenoid radius of curvature and is considered allograft of choice. Allograft options to augment the glenoid defects help to minimize the donor site morbidity associated with autograft harvest. Common surgical complications associated with glenoid defect management include recurrence, hardware failure, chondrolysis, nonunion and resorption of graft especially allograft, and nerve injuries especially the musculocutaneous nerve [76].

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