Arthroscopic Remplissage and Open Latarjet Procedure for the Treatment of Anterior Glenohumeral Instability With Severe Bipolar Bone Loss

J. Christoph Katthagen, M.D., Jack Anavian, M.D., Dimitri S. Tahal, M.Sc., and Peter J. Millett, M.D., M.Sc.

Abstract: Bipolar bone loss in patients with anterior glenohumeral instability is challenging to treat. The goal of the treatment is to restore stability by ensuring that the humeral head remains within the glenoid vault. This can be achieved either with the combination of an arthroscopic Bankart procedure and remplissage (glenoid bone loss <25%), or with a Latarjet procedure (glenoid bone loss >25%). In cases with more severe bipolar bone loss of both the glenoid and the humeral head, the conventional approach has been to lengthen the articular arc of the glenoid and to ignore the Hill-Sachs lesion. However, it has recently been shown that this can still lead to an "off-track" situation with persistent shoulder instability from engagement of the Hill-Sachs on the anterior glenoid. In these cases, the combination of a Hill-Sachs remplissage and the Latarjet procedure can be effective in preventing persistent instability. In this technical note, the surgical technique of an arthroscopic Hill-Sachs remplissage in combination with an open Latarjet procedure is presented.

Severe bipolar bone loss (BBL) in patients with anterior glenohumeral instability (AGI) requires individual treatment strategies depending on the size and location of the bony defects of both the glenoid and the humeral head.[1,2] In such cases with BBL, it is an important factor to define whether the humeral head is on-track or off-track.[3-5] This calculation takes into account the combined bone defects and their locations. In addition, the amount of anterior glenoid bone loss is an essential determinant for the choice of treatment for BBL in AGI. In patients with anterior glenoid deficiency of less than 25%, a combination of an anterior Bankart procedure and posterior remplissage is recommended.[6-8] If the anterior glenoid bone loss exceeds 25% of the anteroposterior expansion, the Latarjet procedure alone is usually indicated.[6,8] In "borderline" cases with distinct BBL of both the glenoid and the humeral head, the combination of a Bankart procedure and a remplissage can severely reduce the capsular volume and restrict the range of glenohumeral motion, especially the range of rotation.[7] As Mook et al. have shown, in cases with more severe BBL treated with the Latarjet procedure alone, the humeral head can still be off-track if the Hill-Sachs lesion is not addressed.[4] In these cases, the combination of a Hill-Sachs remplissage and the Latarjet procedure should be considered.[9] Although conceptually this approach makes sense, performing both procedures together can be technically challenging and has not been described well in the literature. This technical note, therefore, presents the

From the Steadman Philippon Research Institute (J.C.K., D.S.T., P.J.M.) and The Steadman Clinic (J.A., P.J.M.), Vail, Colorado, U.S.A.

The authors report the following potential conflict of interest or source of funding: P.J.M. is a paid consultant for Arthrex; receives royalties from Arthrex and Springer Publishing; has stock or stock options in GameReady and VuMedi; and receives research support from Steadman Philippon Research Institute (corporate sponsorship for Steadman Philippon Research Institute is received from Smith & Nephew, Arthrex, Siemens, and Ossur). J.C.K. has his research position at Steadman Philippon Research Institute sponsored by Arthrex for the calendar year (corporate sponsorship for Steadman Philippon Research Institute is received from Smith & Nephew, Arthrex, Siemens, Ossur).

This work was performed at the Steadman Philippon Research Institute, Vail, Colorado, U.S.A.

Received March 24, 2016; accepted June 21, 2016.

Address correspondence to Peter J. Millett, M.D., M.Sc., The Steadman Clinic & Center for Outcomes-based Orthopaedic Research, Steadman Philippon Research Institute, 181 West Meadow Drive, Suite 1000, Vail, CO 81657, U.S.A. E-mail: drmillett@thesteadmanclinic.com

2212-6287/16253

http://dx.doi.org/10.1016/j.eats.2016.06.006

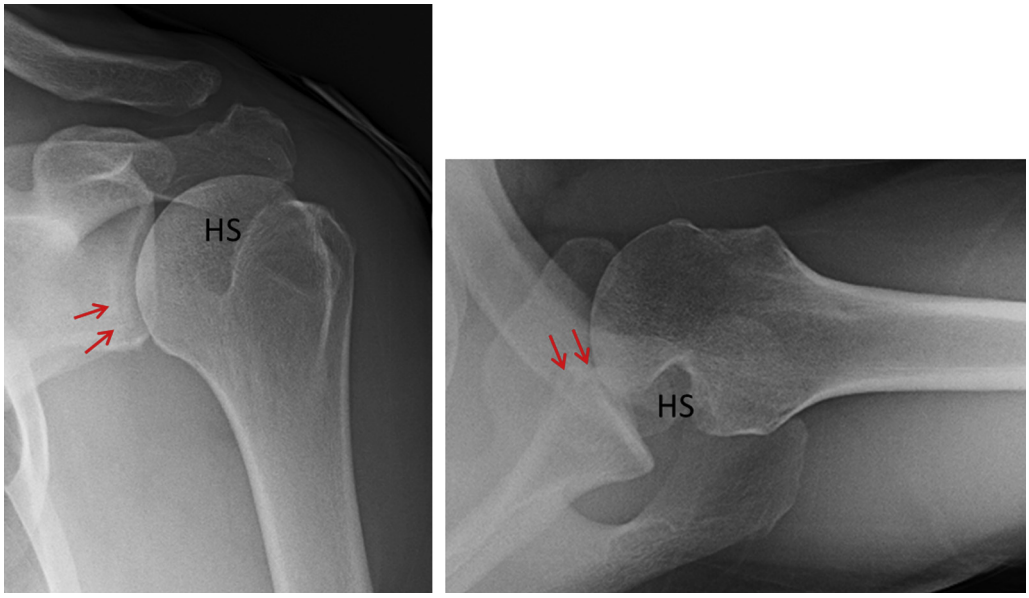

Fig 1. Anteroposterior and axillary x-rays of left shoulder showing severe Hill-Sachs lesion (HS) of the humeral head and loss of anterior glenoid bone contour (red arrows).

surgical technique of an arthroscopic Hill-Sachs remplissage in combination with an open Latarjet procedure.

Surgical Technique

The presented surgical technique of an arthroscopic Hill-Sachs remplissage in combination with an open Latarjet procedure may be indicated in patients with recurrent posttraumatic anteroinferior shoulder instability with combined bony defects involving the glenoid and the humerus (BBL with AGI; Fig 1) for which the evaluation of imaging (x-rays and MRI) reveals that the BBL is off-track and will likely remain off-track after a Latarjet procedure only (Fig 2).[3,4,6] The risks, benefits, and alternative nonoperative and operative treatment options, including bony Bankart repair, remplissage, and the Latarjet procedure, must be discussed.

Informed consent was obtained, and the work described has been carried out in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki).

Preoperative Setup

After adequate regional and general anesthesia, the patient is placed in beach chair position on the operating room table. An examination under anesthesia is performed before the left upper extremity has been prepped and draped in the usual sterile fashion. The examination under anesthesia must include

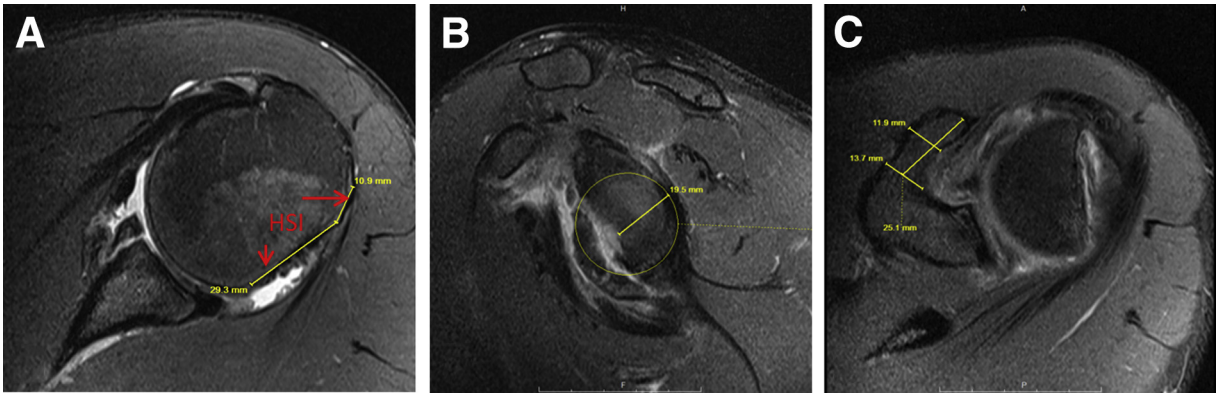

Fig 2. Axial (A, C) and coronal (B) magnetic resonance imaging planes with measurements for predicted on-track/off-track calculation according to Mook et al.[8] The Hill-Sachs interval (HSI, red arrows) measures 40.2 mm (A); the remaining glenoid face measures 19.5 mm (B). The projected glenoid track after Latarjet procedure equals the remaining glenoid face (19.5 mm) plus the maximal width of coracoid (11.9 mm, C) and measures 30.4 mm. The projected glenoid track (30.4 mm) would be smaller than the Hill-Sachs interval (40.2 mm), leaving a persistent off-track situation after Latarjet procedure.

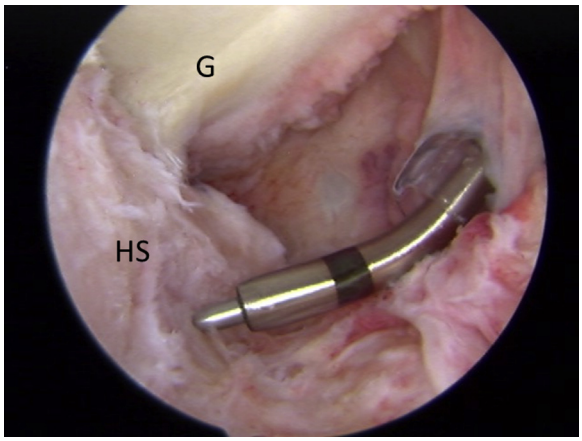

Fig 3. Microfracture of the Hill-Sachs lesion (HS) with a 30° Power Pick (Arthrex); anterior viewing portal; posterior working portal. (G, glenoid.)

confirmation of the grade 3 anterior translation and engagement of the Hill-Sachs lesion.

Establishment of Portals, Glenohumeral Joint Inspection, and Decision Making

A standard arthroscopic posterior viewing portal is established first, and diagnostic arthroscopy is performed with a 30° arthroscope. Next, an anterosuperior working portal is established through the rotator interval and a low-profile 5 mm × 7 cm cannula (Arthrex, Naples, FL) is inserted to facilitate instrumentation. For glenohumeral debridement, a 3.75-mm suction radiofrequency (RF) cautery device (Super TurboVac 90; ArthroCare, Austin, TX) and arthroscopic shaver may be utilized. The anterior-superior labrum, a possible GLAD (glenolabral articular disruption) lesion, and the Hill-Sachs lesion are debrided next (Video 1). Both bony defects must be carefully visualized both posteriorly and anteriorly. If an anterior glenoid bone fragment is present, its bone quality must be assessed. An arthroscopic bony Bankart repair only seems to be a viable option if the bony fragment is of good quality and adequate size.

Preparation of Arthroscopic Remplissage

To perform the combined Latarjet and remplissage, the arthroscope is first placed anteriorly to view and prepare the arthroscopic remplissage. After debriding the Hill-Sachs defect, a 30° Power Pick (Arthrex) is used to microfracture the Hill-Sachs defect (Fig 3) to enhance healing of the infraspinatus tenodesis (remplissage). The arthroscope is then placed separately in the subacromial space and an arthroscopic subacromial decompression with complete bursectomy is performed to allow for good visualization for the remplissage procedure. A posterolateral portal is established to facilitate suture passing and knot tying. Next, with the arthroscope in the anterior portal again, two 3.0-mm biocomposite anchors (SutureTak; Arthrex) are placed in the Hill-Sachs defect at the articular margin (Fig 4). The sutures are passed in mattress configuration through the infraspinatus into the subacromial space and retrieved out through the accessory posterolateral portal (Fig 4). The sutures are not tied at this point given that a Fukuda retractor will later be placed in the glenohumeral joint space to retract the humeral head posteriorly during the Latarjet procedure.

Open Latarjet Procedure

All arthroscopic instruments are removed and the shoulder is reprepped. A longitudinal skin incision is carried out through the skin and subcutaneous tissue for the deltopectoral approach, and the deltopectoral interval is then developed. The conjoined tendon is identified, the coracoacromial ligament is released laterally, and the pectoralis minor tendon is released medially. The coracoid is skeletonized and harvested with an oscillating saw using an angulated saw blade (Arthrex). An approximately 26-mm-long piece of the coracoid should be harvested. The inferior surface is flattened and prepared to achieve a bleeding surface for

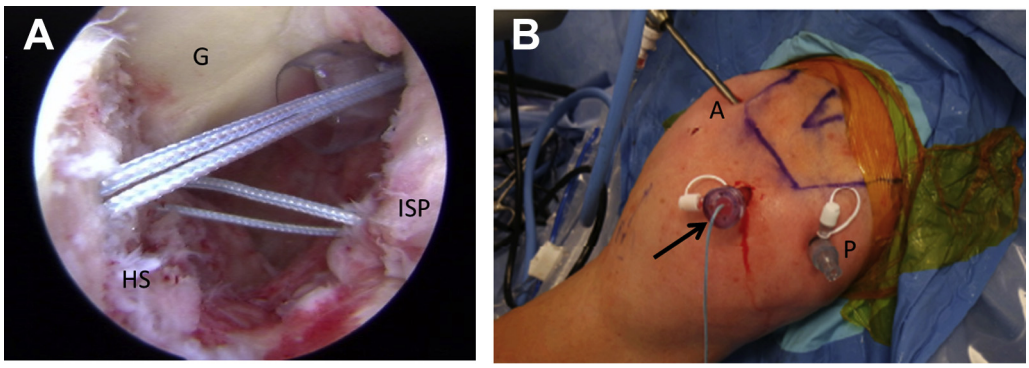

Fig 4. (A) Arthroscopy left shoulder, intra-articular view, anterosuperior viewing portal; anchors placed in Hill-Sachs lesion (HS) and sutures passed through the infraspinatus (ISP). (B) Left shoulder, intraoperative view showing the anterosuperior viewing portal with arthroscope (A), the posterior working portal (P) and the additional posterolateral portal with sutures (black arrow). (G, glenoid.)

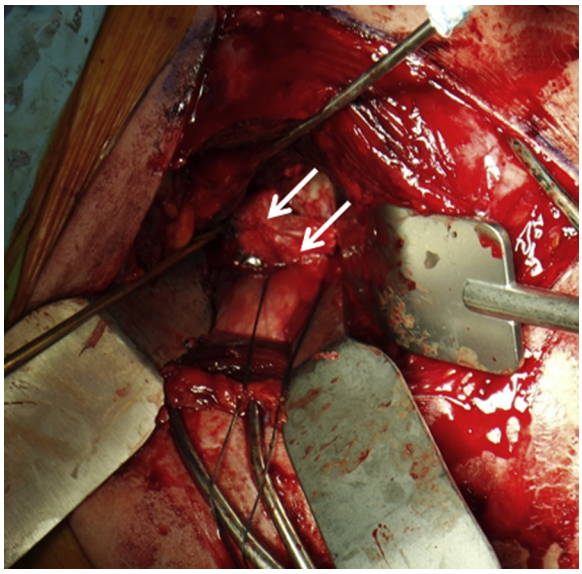

Fig 5. Fixation of the transferred coracoid process (white arrows) to the glenoid neck through a deltopectoral skin incision and a subscapularis splitting approach.

bone healing. Two 3.5-mm drill holes are then drilled for later screw insertion.

Next, a retractor is placed just posterior to the axillary nerve to protect it. The subscapularis is then split in line with its fibers, and an arthrotomy of the joint is performed, elevating the capsule with 2 flaps. A Fukuda retractor is placed in the joint, and the anteroinferior quadrant of the glenoid is exposed. Because the remplissage is not secured at this point, the humeral head can be safely retracted laterally and posteriorly with no disruption of the infraspinatus tenodesis (remplissage). The loose bony Bankart fragment is removed and if present, a GLAD lesion is microfractured (Power Pick, Arthrex). Retractors are placed medially, superiorly, and inferiorly to carefully visualize the glenoid neck, and the anteroinferior glenoid rim is prepared using a 5-mm bone cutter shaver (Arthrex). A 2.5-mm drill hole is drilled in the glenoid rim parallel to the articular surface, and the depth of this screw hole is measured. This length plus the length of the previously drilled 3.5-mm drill hole in the coracoid determines the length of the 3.5-mm screw (DePuy Synthes, West Chester, PA) that is used. The screw is used to indirectly reduce the coracoid. The screw should obtain excellent purchase and the bone coracoid graft is then rotated so that it is flush with the glenoid surface (Fig 5). The superior fixation screw is then drilled through the previously drilled 3.5-mm lag hole in the coracoid and into the glenoid. The length of screw is measured with a depth gauge. A second 3.5-mm screw is placed and must achieve robust fixation of the coracoid to the glenoid.

The wound is then copiously irrigated, and a meticulous capsulorrhaphy is performed with the anteroinferior capsule shifted from inferior to superior and reinforced with the transferred coracoacromial ligament using multiple no. 2 permanent sutures (Ethibond; Ethicon, West Summerville, NJ) in a figure-of-8 configuration. The subscapularis split is also closed laterally with no. 2 permanent sutures (Fig 6). The arm is then placed through a range of motion, and although the shoulder should be quite stable, the Hill-Sachs lesion will still engage at the extremes of motion before completion of the Hill-Sachs remplissage.

Completion of Arthroscopic Hill-Sachs Remplissage

The arthroscope is then put back into the subacromial space via the anterosuperior portal. The remplissage procedure is completed by securing the 2 mattress sutures with sliding, locking Weston knots that are backed up with alternating half hitches (Fig 7). The remaining suture material is cut. The arthroscope is then placed into the joint through the rotator interval to visualize the remplissage. The remplissage effectively makes the Hill-Sachs defect extra-articular (Fig 8). During dynamic assessment, the Hill-Sachs lesion should no longer engage on the transferred edge of the coracoid from the Latarjet procedure.

At this point, the shoulder is copiously lavaged and drained, all arthroscopic instruments are removed, and the portal sites and deltopectoral approach are closed in a layered fashion.

Postoperative Care

Postoperatively, radiographs of the shoulder (AP, axillary, Y-view) should be obtained to verify the

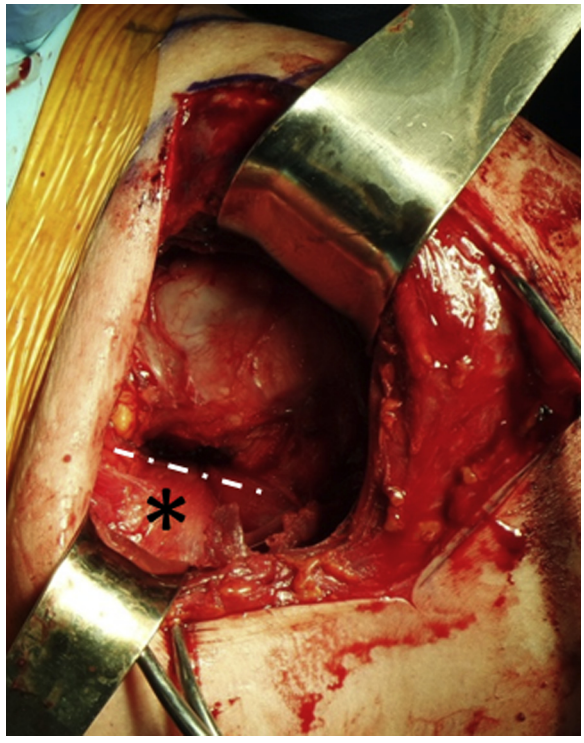

Fig 6. Conjoint tendon (asterisk) running through the subscapularis split (white dotted line).

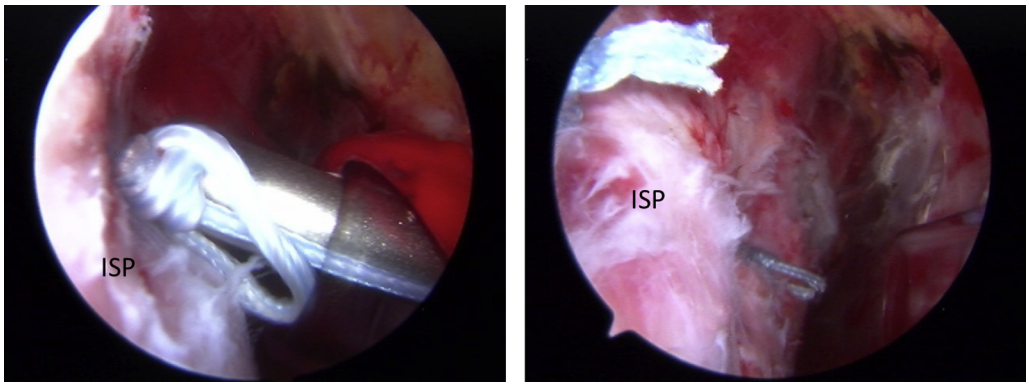

Fig 7. Completion of the remplissage by tying the infraspinatus (ISP) to the Hill-Sachs lesion. Subacromial space through the anterior viewing portal.

position of the transferred coracoid process and the appropriate length of the screws (Fig 9). The operated arm is put in a sling with immediate postoperative early passive range of motion. External rotation is limited to 30° for the first 4 weeks. From the fifth week onwards, full passive range of motion, active-assisted, and active range of motion is started, and the patient is weaned from the sling.

Discussion

The combination of an open Latarjet procedure and arthroscopic remplissage is technically feasible and can provide a stable shoulder with almost no limitation in range of motion. The treatment of patients with BBL and AGI remains challenging, and the proper treatment needs to be determined for each individual patient as no clear guidelines exist on how to address patients with BBL with varying degrees of bone loss.[1,2,8,10] The on-track/off-track principle is helpful to determine whether multiple surgical interventions are necessary at the time of treatment to restore glenohumeral stability.[3] In patients with on-track lesions, the combination of a Bankart repair with a remplissage procedure will typically provide adequate stability and yield good clinical results.[7,8] However, the combination of both procedures was found to significantly reduce the range of glenohumeral rotation.[7] In a current concepts paper, Di Giacomo, Itoi, and Burkhart suggest that in patients with off-track lesions and glenoid bone loss of less than 25%, the combination of Bankart repair with remplissage is indicated.[6] With increasing amounts of BBL, the reduction in capsular volume is presumably increased by the combination of the aforementioned procedures, which may result in more loss of rotational motion. This subject still requires further evaluation.

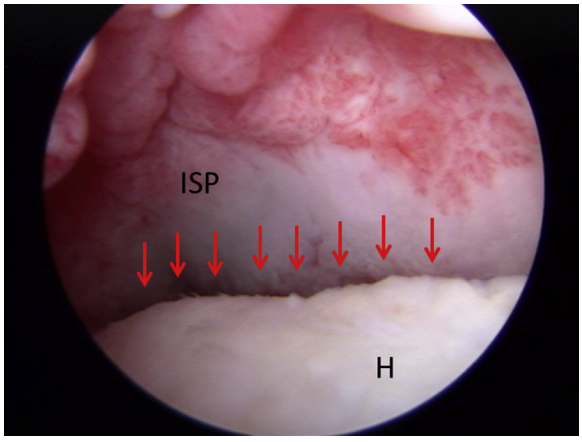

Fig 8. Intra-articular view after completion of the remplissage, with Hill-Sachs lesion now effectively being extra-articular (red arrows). Anterior viewing portal. (H, humeral head; ISP, infraspinatus.)

For patients with BBL and a glenoid deficiency of >25%, a Latarjet procedure alone is recommended in current literature.[6,8] However, Mook et al. recently found that the risk for recurrent instability after the Latarjet procedure is increased in patients with predicted off-track BBL, even after a Latarjet. The prediction is performed by preoperatively calculating how much the glenoid arc will be lengthened after the coracoid is transferred.[4] In such cases, the Hill-Sachs lesion is predicted to engage after Latarjet alone and, in fact, is found to still engage intraoperatively after the Latarjet procedure, suggesting the need for additional stabilization. We are aware of one case report in literature which presents functional results after the combination of an open Latarjet procedure with an arthroscopic remplissage for severe BBL.[9] The patient had no dislocations or any sign of instability, and had significantly improved functional scores at 3.5 years postoperatively.

In the presented surgical technique, the authors suggest to start the procedure with preparation of the remplissage procedure without tying the infraspinatus to the Hill-Sachs lesions. Owing to the anterior glenoid defect the anterior translation is increased, which facilitates the work in the narrow posterior subacromial space. Leaving the sutures untied at this point eases the placement of the Fukuda retractor and the retraction of

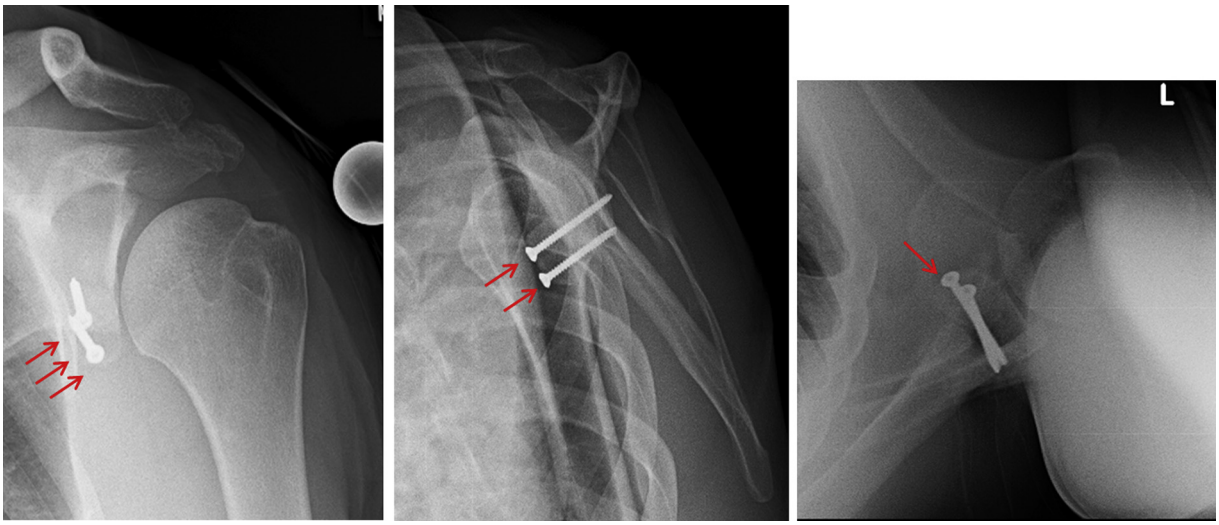

Fig 9. Postoperative x-rays (anteroposterior, Y, and axillary view) showing the transferred coracoid process fixed with 2 cancellous screws (red arrows).

the humeral head posteriorly for the Latarjet procedure. Once the Latarjet procedure is completed, the knots for the remplissage procedure can be tied (Table 1).

Off-track Hill-Sachs lesions have been identified as significant and important risk factors for recurrence of instability and need for revision surgery after arthroscopic Bankart repair and after the Latarjet procedure.[4,5] Furthermore, increasing humeral head and glenoid defect sizes were found to be associated with increasing shoulder instability in a finite-element model.[10] The authors suggested that with increasing defect size, bony reconstruction procedures may be necessary to obtain a stable shoulder. Alternatively to the presented combination of a Latarjet procedure and a Hill-Sachs remplissage, other treatment options with use of allo- and autografts have been described to reconstruct humeral head and anterior glenoid defects.[11-13] However, many of these procedures are more invasive and associated with fairly high complication rates including graft resorption or necrosis in up to 30% of cases.[11,13] Similar to the presented surgical technique of a Latarjet procedure combined with a Hill-Sachs remplissage, the level of evidence regarding dual bone grafting for BBL in AGI is limited to case reports.[14]

Potential advantages of the combination of a Latarjet procedure and a Hill-Sachs remplissage include the minimally invasive approach as compared with open dual grafting techniques and the reduced risk of graft resorption or necrosis (Table 2). A potential disadvantage may be a reduced range of glenohumeral rotation after the remplissage.[7]

In a current systematic review, Longo et al. found that there is little evidence in the literature "to accurately establish which bone defects should be treated with bony procedures and the exact percentage of bone loss leading to higher risk of redislocation in clinical settings."[1] We propose that surgeons who treat patients with large combined BBL should calculate the predicted postoperative glenoid track.[4] If the prediction shows an 'on-track situation' then a Latarjet alone should be sufficient. However, if the prediction shows an 'off-track' situation, then the surgeon should be prepared to address this (1) with a larger bone graft on the glenoid (iliac crest autograft of distal tibial osteochondral allograft), (2) with combined grafting of the glenoid and humerus, or (3) with grafting of the glenoid with a Latarjet and remplissage as was demonstrated in this

Table 1. Pearls and Pitfalls for Arthroscopic Remplissage and Open Latarjet Procedure

Pearls	Pitfalls
Visualization of the glenoid and humeral head defects from posterior and anterior for exact assessment	Overtying the remplissage in a position of excessive internal or external rotation
Preparation of the Hill-Sachs remplissage without tying the knots before the Latarjet procedure	Placement of a screw that is too long for fixation of the coracoid process

Table 2. Potential Advantages and Disadvantages of an Arthroscopic Remplissage and Open Latarjet Procedure

Advantages	Disadvantages
No bone allograft necessary	Potentially reduced range of glenohumeral rotation
Treatment of Hill-Sachs lesion arthroscopically	
Reduced risk of graft resorption/necrosis	

case. The surgical technique presented in this paper can be a valuable treatment option especially for young, active patients with severe BBL of both the glenoid and the humeral head.

Acknowledgment

We would like to thank Chris Jacobsen and Barry Eckhaus of the Department of Technology and Multimedia Communications, Steadman Philippon Research Institute, for their assistance with editing of the technique video.

References

1. Longo UG, Loppini M, Rizzello G, Romeo G, Huijsmans PE, Denaro V. Glenoid and humeral head bone loss in traumatic anterior glenohumeral instability: A systematic review. *Knee Surg Sports Traumatol Arthrosc* 2014;22:392-414.
2. Di Giacomo G, De Vita A, Costantini A, de Gasperis N, Scarso P. Management of humeral head deficiencies and glenoid track. *Curr Rev Musculoskelet Med* 2014;7:6-11.
3. Yamamoto N, Itoi E, Abe H, et al. Contact between the glenoid and the humeral head in abduction, external rotation, and horizontal extension: A new concept of glenoid track. *J Shoulder Elbow Surg* 2007;16:649-656.
4. Mook W, Petri M, Greenspoon JA, Horan MP, Dornan GJ, Millett PJ. An evaluation of the clinical and anatomical predictors of outcomes at a minimum of 2 years following the Latarjet procedure for recurrent anterior shoulder instability with glenoid bone loss. *Am J Sports Med* 2016;44:1407-1416.
5. Locher J, Wilken F, Beitzel K, et al. Hill-Sachs off-track lesions as risk factor for recurrence of instability after arthroscopic Bankart repair. *Arthroscopy* 2016;32:1993-1999.
6. Di Giacomo G, Itoi E, Burkhart SS. Evolving concept of bipolar bone loss and the Hill-Sachs lesion: From "engaging/non-engaging" lesion to "on-track/off-track" lesion. *Arthroscopy* 2014;30:90-98.
7. Merolla G, Paladini P, Di Napoli G, Campi F, Porcellini G. Outcomes of arthroscopic Hill-Sachs remplissage and anterior Bankart repair: A retrospective controlled study including ultrasound evaluation of posterior capsulotenodesis and infraspinatus strength assessment. *Am J Sports Med* 2015;43:407-414.
8. Cho NS, Yoo JH, Rhee YG. Management of an engaging Hill-Sachs lesion: Arthroscopic Remplissage with Bankart repair versus Latarjet procedure [published online June 5, 2015]. *Knee Surg Sports Traumatol Arthrosc.* doi:10.1007/s00167-015-3666-9.
9. Ranne JO, Sarimo JJ, Heinonen OJ, Orava SY. A combination of Latarjet and remplissage for treatment of severe glenohumeral instability and bone loss. A case report. *J Orthop* 2013;10:46-48.
10. Walia P, Miniaci A, Jones MH, Fening SD. Influence of combined Hill-Sachs and bony Bankart defects on range of motion in anterior instability of the shoulder in a finite element model. *Arthroscopy* 2015;31:2119-2127.
11. Saltzman BM, Riboh JC, Cole BJ, Yanke AB. Humeral head reconstruction with osteochondral allograft transplantation. *Arthroscopy* 2015;31:1827-1834.
12. Kraus N, Amphanasap T, Gerhardt C, Scheibel M. Arthroscopic anatomic glenoid reconstruction using an autologous iliac crest bone grafting technique. *J Shoulder Elbow Surg* 2014;23:1700-1708.
13. Waterman BR, Chandler PJ, Teague E, Provencher MT, Tokish JM, Pallis MP. Short-term outcomes of glenoid bone block augmentation for complex anterior shoulder instability in a high-risk population. *Arthroscopy* 2016;32:1784-1790.
14. Peshin C, Jangira V, Gupta RK, Jindal R. Neglected anterior dislocation of shoulder with large Hill-Sachs lesion and deficient glenoid: Treated by autogenous bone graft & modified Latarjet procedure. *J Clin Orthop Trauma* 2015;6:273-276.