Technical Note

Arthroscopic All-Inside Remplissage Technique With Knotless Tape Bridge for Hill-Sachs Lesions

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Abstract: The arthroscopic remplissage procedure has been described to successfully treat engaging Hill-Sachs lesions and improve shoulder stability. Several variations of this technique have been described, including remplissage with 1 or 2 knotted or knotless anchors, remplissage with double or triple bridging pulleys, and remplissage with or without a subacromial view. However, most techniques use anchors in combination with round sutures. This article describes an all-arthroscopic articular knotless remplissage technique using a strong, flat, double-strand suture tape bridge fixed with 2 small anchors under direct joint visualization and reduction of the capsule and infraspinatus without requiring a subacromial view.

Anterior shoulder instability is the most common form of shoulder instability and is frequently related to a traumatic injury.[1] Many soft-tissue and osseous procedures have been described to treat this condition, with varying degrees of consensus among shoulder surgeons dependent on the associated injuries.[2,3] The Hill-Sachs lesion, a compression fracture of the humeral head after its impaction on the anterior glenoid rim, is characteristic of patients experiencing traumatic anterior glenohumeral dislocations, with a reported prevalence of 77% to 100%.[4] It was first described by Malgaigne[5] in 1847 and was then reviewed and popularized by Hill and Sachs in 1940.[6]

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Hill-Sachs "remplissage," a French word meaning "to fill in," which was described for the first time in 2004 by Wolf and Pollack,[7] is a frequently used arthroscopic procedure to treat Hill-Sachs lesions that seeks to prevent engagement with the anterior glenoid rim and involves capsulomyodesis of the infraspinatus muscle using anchors to fix it into the humeral head defect.[8] This procedure has been used to successfully treat engaging Hill-Sachs lesions, obtaining good results and improvement in shoulder stability.[9-11]

Since the first description of the aforementioned technique, several variations have been described.[12] Recently, knotless techniques have been reported to facilitate suture handling and reduce surgical times.[13] In this technical note, an arthroscopic knotless remplissage technique with direct intra-articular visualization and without subacromial dissection is described, using a strong double-stranded suture tape fixed with two 3.9-mm threaded anchors. The advantages and disadvantages of this technique are discussed in Table 1.

Surgical Technique

A step-by-step description of the technique is shown in Figure 1. The surgical technique is demonstrated in Video 1.

Patient Setup and Arthroscopic Diagnosis

The patient is placed in the lateral decubitus position with approximately 30° of posterior obliquity to ensure that the glenoid is parallel to the floor. Posterior dorsal

Table 1. Advantages and Disadvantages

Advantages	
	The all-inside knotless technique allows a complete glenohumeral view through a single superolateral portal and simplifies the procedure while decreasing the number of steps and surgical time.
	The low-profile knotless configuration avoids bulky knots.
	The tape-loaded anchor passes through the infraspinatus and the capsule in 1 step without additional suture-passing steps.
	The double tape-bridge configuration can potentially achieve remplissage with a larger footprint compression area that improves healing at the bone-tendon interface.
	Flat suture tape produces less damage to the tendon compared with traditional round sutures.
Disadvantages	
	The technique requires blind passage of the suture tape between the deltoid and infraspinatus from the inferior percutaneous anchor to the standard posterior portal.
	Tensioning of the tape must be performed manually prior to anchor insertion in the bone socket.
	Remplissage may result in loss of external rotation.

and sacral supports are placed to maintain the position. Traction is applied to the arm with a traction foam sleeve (3-Point Shoulder Distraction System; Arthrex, Naples, FL). The bony structures and arthroscopic portals are drawn with a sterile marker (Fig 2A).

Starting from a standard posterior portal, the surgeon performs a diagnostic arthroscopy to assess the size of the Hill-Sachs lesion and the presence of any additional pathology. The arthroscope is then switched to an anterosuperolateral (ASL) portal, created under direct visualization, to better evaluate the glenoid surface, labrum, and Hill-Sachs lesion (Fig 2B). At this stage, the exposed Hill-Sachs lesion is debrided using an arthroscopic curette and shaver until subchondral bleeding bone is exposed.

Inferior (Distal) Anchor Placement

With the arthroscope remaining in the ASL portal, a spinal needle is percutaneously inserted to determine the correct location and direction of anchor placement at the middle of the humeral defect (Fig 3). A small percutaneous incision is made with a No. 11 blade, and a punch is introduced to create the socket for the anchor. Before removal of the punch, a half-pipe metallic cannula (Arthrex) is introduced to allow a quick exchange and easy introduction of the anchor through the soft

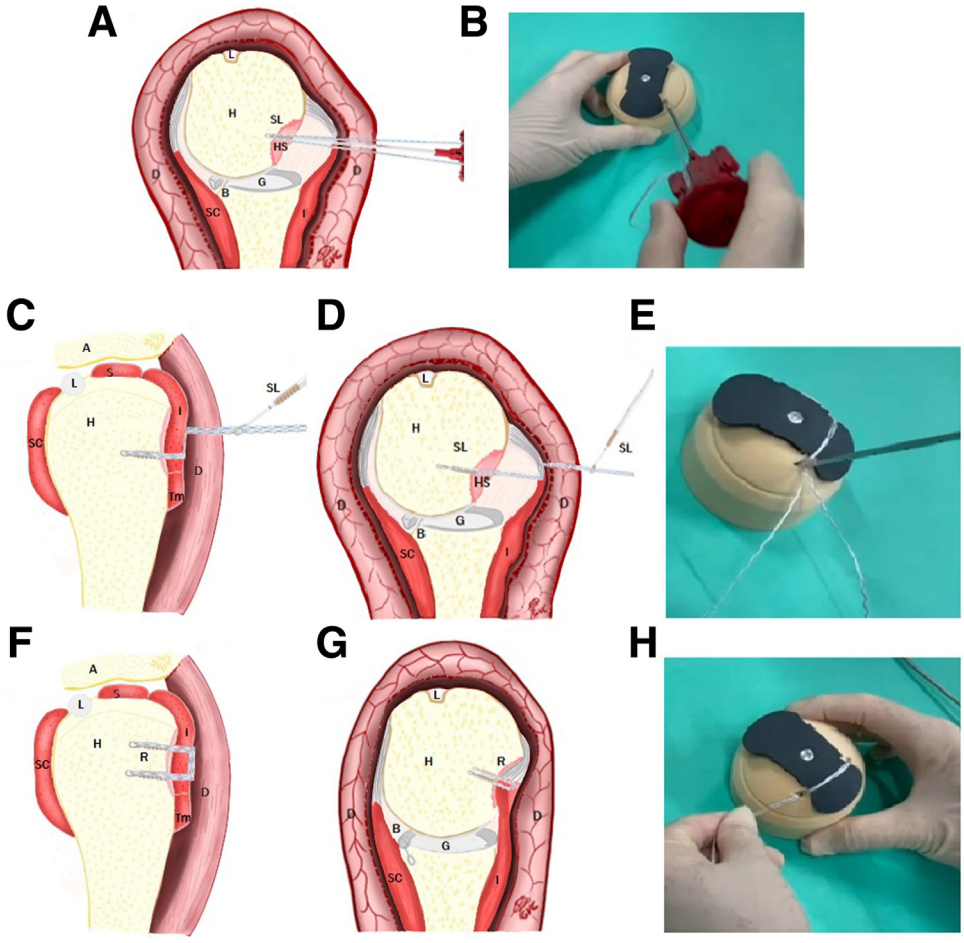

Fig 1. Step-by-step arthroscopic remplissage technique with knotless tape bridge for Hill-Sachs lesions. (A, B) Axial views of Bankart and Hill-Sachs lesions. (B) Introduction of the first anchor. (C, D) Sagittal and axial views. The second anchor is preloaded with both strands of the tape suture. (E) Superior anchor placement. (F-H) Sagittal view, axial view, and schematic representation of both anchors with bridged suture tapes fixing the capsule and infraspinatus into the defect. (A, acromion; B, Bankart lesion; D, deltoid; G, glenoid; H, humeral head; HS, Hill-Sachs lesion; I, infraspinatus; L, long head of biceps; R, remplissage; S, supraspinatus; SC, subscapularis; SL, anchor; Tm, teres minor.)

tissue. The first 3.9 × 17.9—mm SwiveLock suture anchor (Arthrex) is preloaded with 1.7-mm-wide ultrahigh-strength suture tape (Arthrex) and fixed into position in the socket, with both tape ends being kept at an equal length. An arthroscopic tape retriever from the standard posterior portal can be used to improve visualization of anchor entry by pushing the capsule away from the threaded tip.

Capsulolabral Repair

At this point, the lateral strap of the 3-point traction system is set up to improve access to the glenohumeral joint and the axillary pouch. Before placement of the superior anchor, concomitant lesions of the labrum or capsule are addressed, with particular attention being paid to the anteroinferior capsulolabral complex because the success of this technique is dependent, in part, on an adequate anteroinferior bumper. After this repair is completed, preparation of the superior anchor is commenced (Fig 4).

Percutaneous Tape Transport

The following step should be performed after the labral repair to keep the posterior articular space from collapsing, which would hinder articular visualization. Using an arthroscopic tape grasper through the previous accesory incision used to place the first anchor, both tape strands are transported percutanously over the infraspinatus and under the deltoid muscle to the posterior portal (Fig 5A). This effectively creates a wide double tape bridge over the infraspinatus for remplissage. At this point, traction of the tape sutures can demonstrate the correct filling and reduction of the capsule and infraspinatus to the defect while direct visualization from the ASL portal is maintained (Fig 5 B-D).

Superior (Proximal) Anchor Placement

With direct visualization from the ASL portal, external rotation is applied to the arm. The posterior cannula placed through the standard posterior portal during Bankart repair is withdrawn. A spinal needle is then introduced through the posterior portal, entering the capsule lateral to the initial entry point to the joint. It should pass through the infraspinatus tendon halfway between the medial and lateral aspects of the Hill-Sachs lesion to avoid excessive filling of the lesion during remplissage. The needle is then replaced with the punch and, before socket creation, adequate tension of the tissue between both anchors is demonstrated by presenting the punch in the superior anchor site. The socket for the superior anchor is created and, following the same procedure used in distal anchor placement, the half-pipe metallic cannula (Arthrex) is used to exchange and easily introduce the second 3.9 × 17.9—mm SwiveLock suture anchor, preloaded with both tape strands. To achieve a successful repair, keeping the arm in neutral rotation and ensuring sufficient tension of the tapes before anchor placement are critical. The remaining tape limbs are cut, completing the remplissage procedure. The final construct is inspected, and external rotation with anterior translation is applied to confirm glenohumeral stability (Fig 6). A graphical representation of the completed remplissage technique is shown in Figure 7. Pearls, pitfalls, and limitations of this technique are presented in Table 2.

Postoperative Care

During the postoperative phase, the shoulder is immobilized with a sling in neutral rotation for 3 weeks. Immediate pendulum, passive-assisted flexion, and isometric deltoid exercises, as well as strengthening of the scapular stabilizers, are encouraged. Additionally, full range of motion of the hand and elbow with the shoulder in adduction and less than 20o of active external rotation is allowed.

The sling is removed at 3 weeks postoperatively, and active-assisted exercises of the shoulder are initiated.

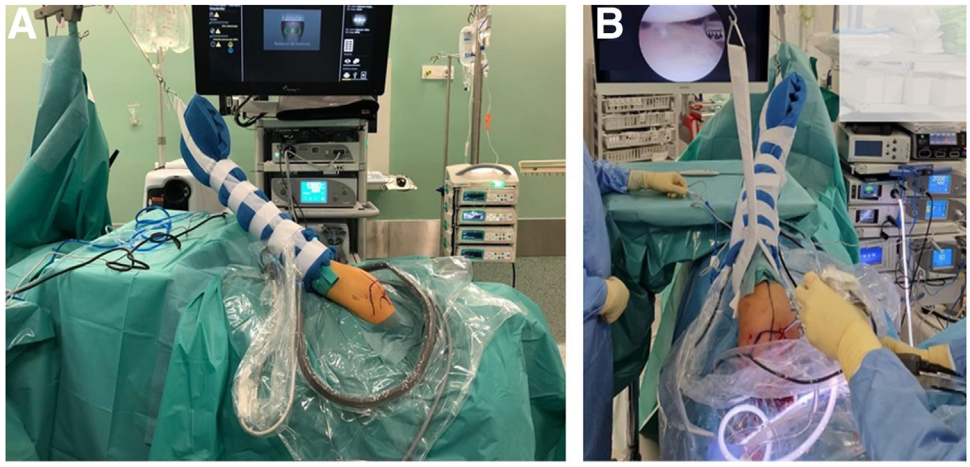

Fig 2. (A) External view of preoperative setting with patient placed in lateral position with right arm fixed with traction system. (B) Intraoperative external view; the surgeon achieves full visualization of the joint's anterior, inferior and posterior aspects with the scope through the anterosuperolateral portal. .

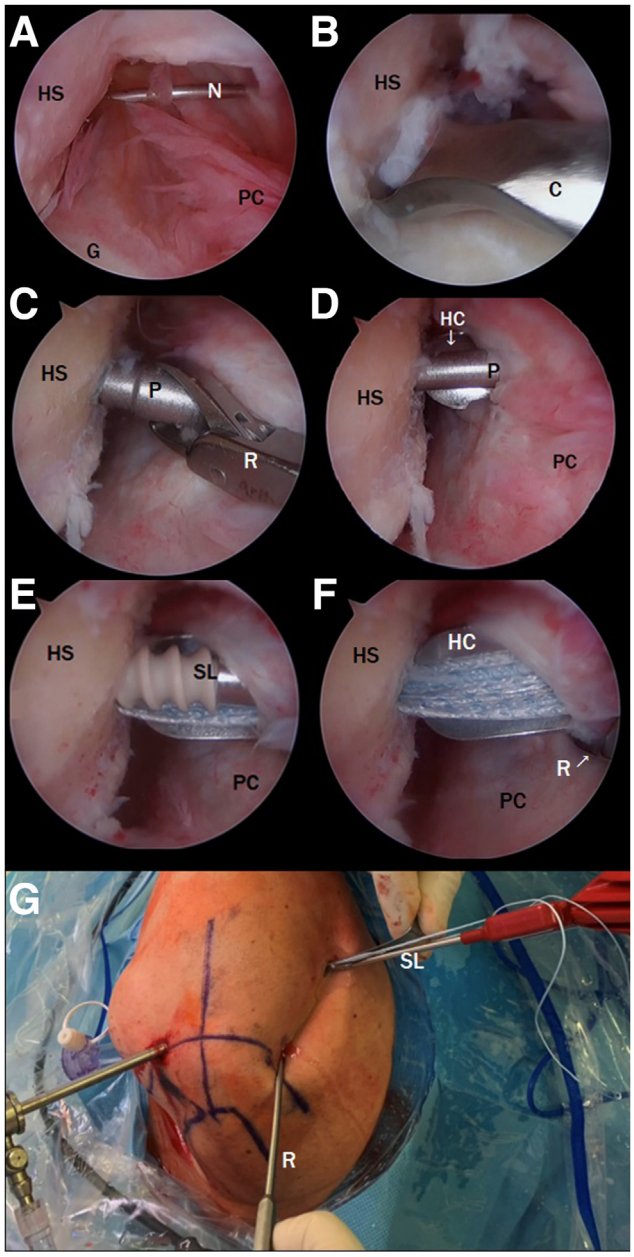

Fig 3. Arthroscopic views (A-F) and external view (B) of right shoulder with patient in lateral position. (A) A spinal needle is inserted percutaneously through the posterior capsule over the center of the defect. (B) The humeral head defect is debrided with a curette. (C) An arthroscopic retriever improves visualization of punch entry. (D) A half-pipe metallic cannula facilitates anchor insertion. (E) The first anchor is fixed into the socket. (F) The anchor is completely introduced, and both suture tape strands are prepared to be transported to the posterior standard portal, where they are loaded into the second anchor. (G) External view of first anchor through percutaneous accessory posterior portal and arthroscopic retriever through standard posterior portal. (C, curette; G, glenoid; HC, half-pipe cannula; HS, Hill-Sachs lesion; N, spinal needle; P, punch; PC, posterior capsule; R, arthroscopic retriever; SL, anchor.)

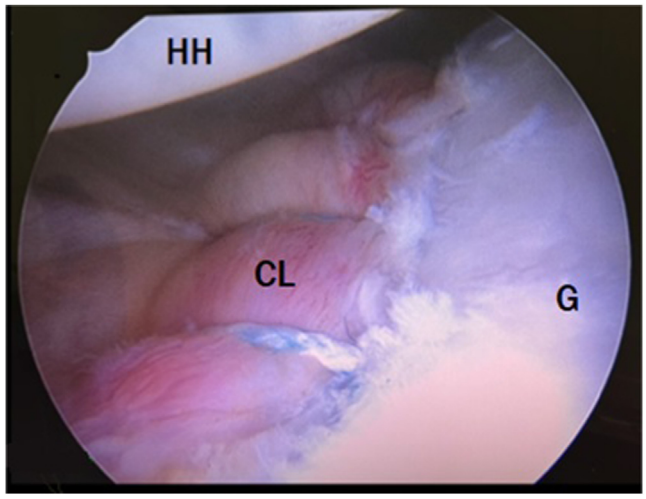

Fig 4. Arthroscopic view of right shoulder from anterosuperolateral portal with patient in lateral position. Bankart repair with all-suture anchors, restoring the bumper effect. (CL, capsulolabral complex; G, glenoid; HH, humeral head.)

Progressive external rotation stretching exercises are permitted at 4 to 6 weeks to achieve full range of motion. Resistance strengthening exercises are incorporated at 6 weeks. Return to sports is allowed at 4 months postoperatively.

Discussion

Numerous arthroscopic surgical techniques have been described to treat anterior shoulder instability.[12] Since the advent of shoulder arthroscopy, arthroscopic Bankart repair has become the most widely used technique to treat this pathology.[2] It has subsequently become evident that anterior capsulolabral complex reconstruction alone is insufficient in patients with glenoid bone loss greater than 25% (i.e., "inverted-pear" glenoid), with a failure rate as high as 61% described by Burkhart and De Beer.[9]

Even in the absence of glenoid bone loss, a humeral bone defect, in the form of a Hill-Sachs lesion, can lead to a failed Bankart repair. The dislocation event pushes the humeral head anteriorly into contact with the anterior glenoid rim, causing a compression fracture along the posterosuperolateral aspect of the humeral head. Subsequently, recurrent dislocations intensify the erosion of the anterior edge of the glenoid, enhancing the likelihood of engagement between the glenoid and the Hill-Sachs lesion, leading to chronic instability.[15] This has been highlighted by the "engaging" concept and, more recently, the "off-track" concept of the Hill-Sachs lesion, with its treatment also becoming a matter of concern.[9,16-18] The remplissage technique, as a treatment for an engaging Hill-Sachs lesion, is best understood using the glenoid track concept. The

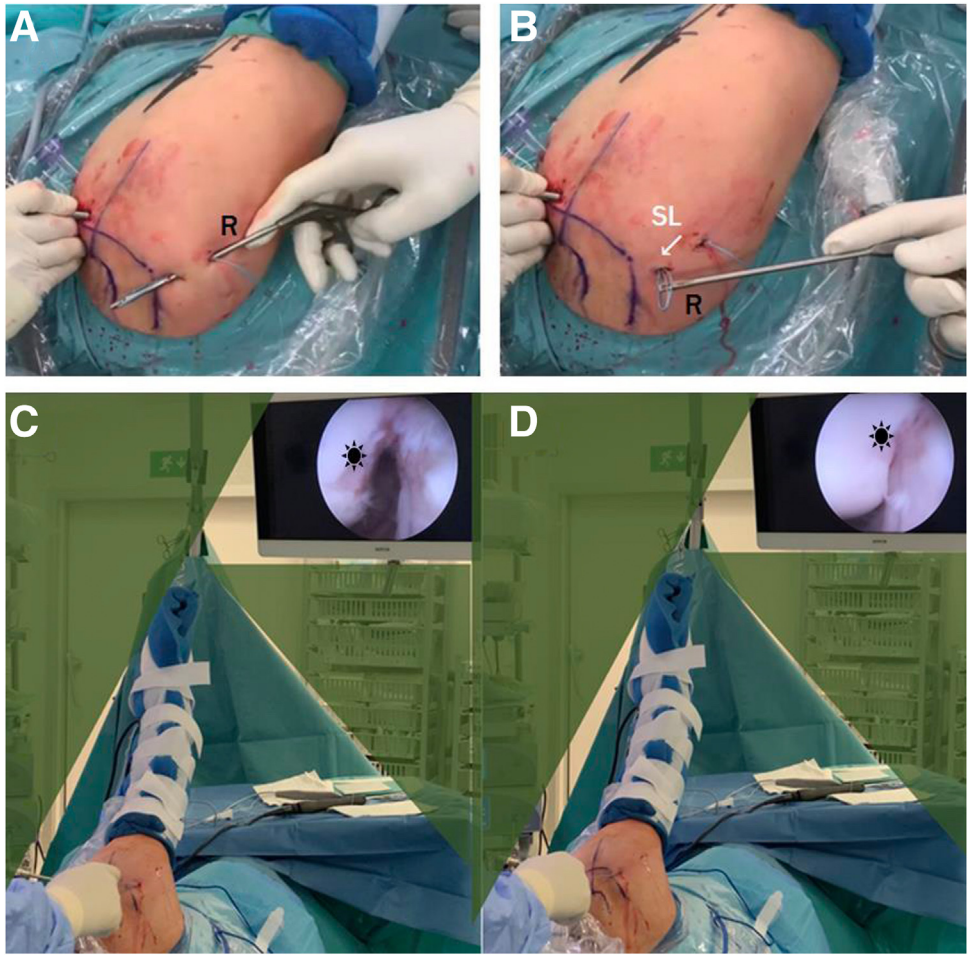

Fig 5. External views of right shoulder with patient in lateral position. (A, B) Using an arthroscopic tape retriever (R), both tape strands are transported percutaneously over the infraspinatus and under the deltoid muscle to the standard posterior portal. (C, D) Traction of the tape sutures before fixation can demonstrate the filling of the defect under direct visualization from the anterosuperolateral portal (black stars) before placement of the second implant. (SL, anchor.)

glenoid track is equivalent to 83% of the glenoid width, accounting for any anterior defect. If the Hill-Sachs lesion lies medial to the calculated track, it is considered off-track and should be addressed with the remplissage procedure.[16]

Recent studies have shown that bipolar lesions with an anterior glenoid defect less than 25% and an off-track Hill-Sachs lesion may be addressed with capsulolabral reconstruction in addition to the remplissage procedure, with satisfactory results regarding recurrence rate, return to sports, and improvement in pain and shoulder function.[14,15,19-22] Similarly, Bankart repair with concomitant remplissage has been compared with the Latarjet procedure for the treatment of bipolar lesions with subcritical glenoid bone loss, with no statistically significant differences found.[23] Furthermore, Horinek et al.[24] reported a study of more than 250 patients with 2-year follow-up showing similar outcomes, fewer complications, and a lower recurrence rate after Bankart repair in addition to the remplissage technique compared with the Latarjet procedure.

Defining the percentage of "critical" bone loss is paramount to standardizing treatment. The definition of critical bone loss may be lower than the percentages of 20% to 25% described in the literature.[25] Arthroscopic reconstruction of the anterior glenoid with greater anterior bone loss and an off-track lesion should be performed with either autograft or allograft, with or without the remplissage technique. Nonetheless, further studies are needed to achieve greater consensus.[26-28]

The aforementioned arthroscopic remplissage procedure was first described by Wolf and Pollack[7] (2004) to treat Hill-Sachs lesions.[29] Since then, different types of arthroscopic remplissage techniques have been described.[12] Remplissage using 1 or 2 anchors, remplissage with a double pulley, and remplissage via knotted or knotless techniques are just a few of the multiple options that can be found in the current literature.

Koo et al.[12] modified the remplissage technique of Wolf and Pollack[7] by including a double-pulley system to fix the infraspinatus into the Hill-Sachs lesion using a

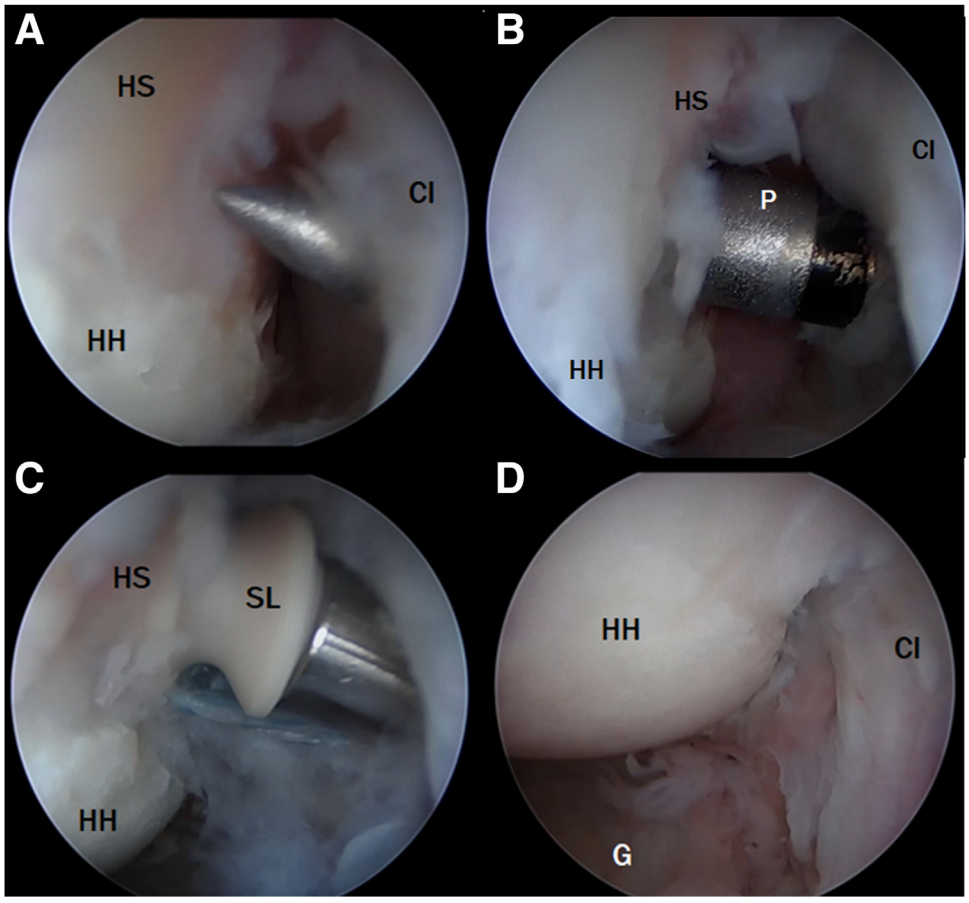

Fig 6. Arthroscopic views of right shoulder with the patient in lateral position. (A) The punch is introduced through the standard posterior portal, lateral to the initial joint entry point. (B) The bone socket for the second, superior anchor is created with the punch. (C) A half-pipe metallic cannula facilitates the introduction of the second anchor, preloaded with both strands of the tape suture. (D) Final view with capsule and infraspinatus reduced and fixed into the defect. (CI, capsule and infraspinatus; G, glenoid; HH, humeral head; HS, Hill-Sachs lesion; P, punch; SL, anchor.)

transtendinous approach, imitating the PASTA (partial articular supraspinatus tendon avulsion) bridge technique described by Lo and Burkhart[30] for PASTA lesions. In 2019, Hirahara et al.[13] first reported the arthroscopic PASTA bridge knotless remplissage technique to treat engaging Hill-Sachs lesions. In this

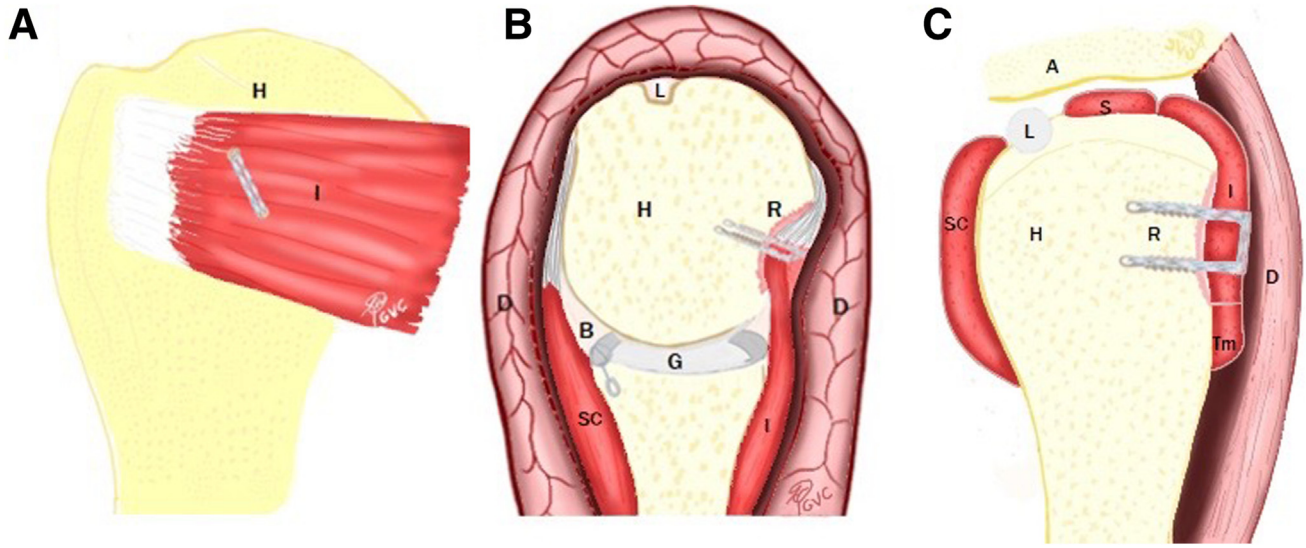

Fig 7. Coronal (A), axial (B), and sagittal (C) views of arthroscopic remplissage technique with knotless tape bridge for Hill-Sachs lesion. (A, acromion; B, Bankart lesion; D, deltoid; G, glenoid; H, humeral head; I, infraspinatus muscle; L, long head of biceps; R, remplissage; S, supraspinatus muscle; SC, subscapularis muscle; Tm, teres minor.)

Table 2. Pearls, Pitfalls, and Limitations

Pearls
The use of a percutaneous needle is crucial to determine the level of inferior anchor placement.
Placement of the inferior anchor through an accessory posterior portal promotes parallel implant configuration and adequate tape-bridge length.
A blunt half-pipe metallic cannula over the punch allows a quick exchange and easy introduction of the anchor through the soft tissue, avoiding collapse of the space between the Hill-Sachs lesion and the posterior capsule.
Use of a suture tape retrieval device facilitates smooth suture tape transport from the inferior anchor to the superior standard posterior portal.
To achieve correct positioning of both anchors, they should be positioned no further than the midline of the defect.
There is no need for subacromial space visualization.
The camera through the anterosuperolateral portal leaves the standard posterior portal free to introduce an arthroscopic tape retriever or a probe to help with anchor introduction through the soft tissue.
Pitfalls
Performing remplissage before Bankart repair collapses the posterior articular space, complicating labral repair.
An insufficient anteroinferior bumper can lead to failure even with remplissage.
Inadequate tensioning of the suture tapes will leave slack in the construct and diminish compression.
Careful suture management is crucial to avoid suture tape damage while treating concomitant injuries.
Limitations
An experienced shoulder surgeon is required.
Specific suture tapes and implants are needed.

technique, suture handling is performed through direct visualization in the subacromial space. Two years later, Callegari et al.[31] described an all-inside knotless technique, arguing that the efficiency of the procedure was improved by avoiding the subacromial space. Most recently, in 2022, McQuivey et al.[32] reported a technique using knotless all-suture anchors with a single skin incision, arguing that greater bone preservation is achieved and revision surgery, if required, is facilitated.

Biomechanical studies have also been performed to investigate the effects of the number and location of anchors when performing the remplissage technique. Published results have shown that Bankart repair plus the remplissage technique achieves greater shoulder stability than Bankart repair alone and that medially placed anchors obtain greater glenohumeral joint stability but with loss of range of motion.[33]

In this article, an all-inside arthroscopic knotless remplissage technique using a strong double-stranded 1.7-mm suture tape fixed with 2 small anchors (3.9 mm) is described. This technique can potentially create a stronger and wider footprint compression between the capsule-infraspinatus complex and the posterosuperior defect of the humeral head, with no need to dissect the subacromial space, reducing surgical time. Furthermore, using smaller implants leads to greater bone preservation, facilitating revision surgery.

In conclusion, the described procedure yields a strong, reliable, and reproducible construct with potential benefits that could likely decrease the rate of complications and failed stabilization procedures for shoulders with primary instability.

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