



The remplissage technique

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ABSTRACT

Remplissage is the procedure of filling the Hill-Sachs lesion of the humeral head with the infraspinatus tendon and posterior capsule. This is indicated as adjuvant procedure to Bankart repair in patients with recurrent dislocation of shoulder with large, engaging or off-track Hill-Sachs lesion. This helps to convert the intra articular lesion to an extra-articular one. Arthroscopic remplissage technique was originally described in 2008. Various modifications have been described since then. Over the last decade, case series and comparative studies have shown excellent results in terms of reducing recurrence rates and improving functional outcome. They have been reported with minimal or no complications. This article describes the technical aspects of performing remplissage and the author's preferred way of doing it.

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1. Hill Sachs defect

Hill and Sachs described the bony defect of the posterolateral humeral head as an unrecognised complication of shoulder dislocation in 1940.¹ The incidence of Hill-Sachs lesion increases with an increase in number of dislocations ranging from 65% to 67% after the initial dislocation and from 84% to 93% after recurrent dislocations.^{2,3}

X-rays are not reliable for the assessment of Hill-Sachs lesion, though Anteroposterior view with arm in internal rotation may reveal the defect if it is significant. Sagittal and axial CT images are useful and reproducible in measuring the size of the Hill-Sachs lesion. 3D CT gives a much more impactful visual interpretation of the extent of the lesion and its relation to the glenoid track.

2. Hill- Sachs lesion as risk factor for recurrence

Humeral side Hill-Sachs defect has been reported to be one of the significant risk factors for recurrence after arthroscopic Bankart repair in patients with recurrent anterior shoulder instability.^{4–7} Burkhart and Joe De Beer described 67% recurrence of dislocation in the presence of glenohumeral bone defect compared to 4% when there is no bony defect in their case series of arthroscopic Bankart repair.⁴

Whether the Hill-Sachs lesion engages with the glenoid depends on the size and location of the Hill-Sachs lesion relative to the width of the glenoid. Although the engaging Hill-Sachs lesion has been recognized as a risk factor for recurrent anterior instability, there has been no generally accepted method for quantifying the Hill-Sachs lesion.

Itoi et al. described a radiological method of quantifying bipolar bone loss, using the concept of the glenoid track.^{8–10} When the shoulder is in abduction and external rotation and moves along the end range of motion, the glenoid shifts along the posterior margin of the humeral head. This contact zone of the glenoid created on the humeral head along the end range of motion is called the 'glenoid track'. A Hill-Sachs lesion that is located more medially than the medial margin of the glenoid track is defined as an off track Hill-Sachs lesion.

Di Giacomina et al. have described this measurement as follows^{10,11}: First Glenoid Track (GT) is calculated. The diameter of the inferior glenoid (D) is measured, from 3DCT scan en face view of contralateral glenoid. 83% of this normal glenoid width is taken and the width of glenoid bone loss (d) from affected side is subtracted from this value to give the width of glenoid track ($GT = 0.83 D - d$). Next, the Hill-Sachs Interval (HIS) is calculated. The HIS is the distance from the rotator cuff attachments to the medial rim of the Hill-Sachs lesion and is equal to the width of the Hill-Sachs lesion (HS) plus the width of the intact bone bridge (BB) between the rotator cuff and the Hill-Sachs lesion. ($HIS = HS + BB$). If the width of Hill-Sachs Interval is less than the width of Glenoid Track ($HIS < GT$), it is an on track or non-engaging lesion. If the width of

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Hill-Sachs Interval is more than the width of Glenoid Track (HIS > GT), it is an off track or engaging lesion. In this group, Di Giacomo and Itoi suggested remplissage or Latarjet procedure, depending on the glenoid defect size and risk of recurrence.

3. Ways to address the engaging Hill-Sachs lesion

In presence of large, engaging or off-track Hill-Sachs lesion, there is a high risk of recurrence if one plans to perform only soft tissue labral/capsular repair. Traditionally, several techniques have been described to avoid engagement between the Hill-Sachs lesion and the anterior glenoid rim. This can be achieved by either reducing the range of motion in external rotation or filling the humeral head defect. The former includes anterior soft tissue shortening or rotational osteotomy of the humerus.^{6,12} The latter includes filling the lesion with a bone graft or soft tissue.¹³

4. Open remplissage

The transfer of the infraspinatus tendon with or without the greater tuberosity has been used to successfully fill defects smaller than 40% of the articular surface. Weber initially described a combined deltopectoral and posterior approach.¹⁴ The posterior deltoid is split to reveal the infraspinatus tendon. For smaller defect <25% of the articular surface, the infraspinatus tendon is dissected off from its attachment, then mobilised and sutured into the Hill-Sachs defect. For larger defects measuring 25–40% of the articular surface, the greater tuberosity can be osteotomized and secured into the defect with screws. Connolly further described an open procedure of infraspinatus tenodesis into the humeral head defect.¹⁵

5. Arthroscopic remplissage: the original technique

Wolf et al. first described the arthroscopic variation of infraspinatus tenodesis, which they termed 'Remplissage'.^{16,17} Remplissage is derived from the root verb 'remplir', which translates to 'filling' in French. This is because the humeral head defect was filled with the infraspinatus tendon. Following preparation of the glenoid neck and labrum for Bankart repair, visualization of the bony defect was done through the anterosuperior portal. A bone bed was prepared. Two single loaded suture anchors were placed at the superomedial and inferomedial aspects of the Hill-Sachs lesion through a posterior or posterior accessory portal. Mattress sutures were placed on the infraspinatus and posterior capsule and sutures were tied in a blind fashion in the subdeltoid space. This was followed by anterior labral repair. Postoperatively, the arm was kept immobilized for 6 weeks, succeeded by gradual mobilization.

Arthroscopic remplissage has become very popular with shoulder surgeons in the present era, and various modifications have been described. Many clinical papers have demonstrated an excellent outcome of remplissage combined with Bankart repair with reported recurrence rate between 0 and 15% (See Table 1).^{18–31}

No recurrent dislocation was observed in the remplissage group when remplissage with Bankart repair was compared with Bankart repair alone, though no significant difference in Rowe score or UCLA score was revealed among the 2 groups.²²

Better functional score and lower risk of recurrence have been observed in remplissage combined with arthroscopic Bankart repair when compared with osteochondral substitute grafting for engaging Hill-Sachs lesion.³²

Regarding the range of motion and return to sports, Boileau et al. reported that the reduction in external rotation after the remplissage was 8° in adduction and 9° in abduction in their series of 42 patients with large engaging Hill-Sachs lesion.²³ In their series, return to sports at the preinjury level was only 68%. Therefore, usage of remplissage in overhead sports athlete with large, engaging or off-track Hill-Sachs lesion should be carefully considered.

Recently, Domos et al. reported their results of remplissage and Bankart repair in 20 high risk collision athletes with non-engaging Hill-Sachs lesion.³⁰ They reported good outcome, lowered recurrence rate and only a mean difference of external rotation in adduction by 10°. In their series, they reported a 100% return to sports. Therefore, usage of remplissage in collision athletes with small non-engaging Hill-Sachs lesion is recommended, seeing as it improves their ability to return to pre-injury level of sport.

6. Indications for arthroscopic remplissage

1. Recurrent shoulder dislocation with large engaging or off-track Hill-Sachs lesion with <25% anterior glenoid bone loss.
2. In revision procedures for failed instability surgery.

7. Author's preferred technique

Under general anaesthesia, the patient is placed in lateral decubitus position with arm suspended with 6–8 pounds of distal traction to keep the shoulder at approximately 30 degrees of abduction and 15 degrees of forward flexion.

After sterile preparation and draping, a posterior viewing portal is made 2 cm inferior and 2 cm medial to the posterolateral corner of the acromion in the posterior soft spot. A thorough diagnostic arthroscopy is performed. The glenoid, humeral bone loss and

Table 1
Results of arthroscopic remplissage and technique.

Author	year	Sample No	mean follow/up	number of anchors	knot tying	Recurrence rate
Haviv et al. ¹⁸	2011	11	30 m	1 or 2 anchors	Blind	0%
Zhu et al. ¹⁹	2011	49	29 m	1 or 2 anchors	Subacromial	8.2%
M J Park et al. ²⁰	2011	20	29 m	1 or 2 double loaded anchors	Blind	15%
Nourissat et al. ²¹	2011	15	27 m	2 anchors	subacromial	1/15 failure
Franceschi et al. ²²	2012	25	24 m	1 or 2 double loaded anchors	Blind	0%
Boileau et al. ²³	2012	47	24	2 single loaded anchors	Blind	2%
Sang-Hun Ko et al. ²⁴	2013	12		two anchors	Blind	
Wolf et al. ²⁵	2014	45	58 m	2 single loaded anchors	—	4.4%
Garcia et al. ²⁶	2015	10	40 m		—	20%
Brilake et al. ²⁷	2016	48	37 m			
Nam Su Cho et al. ²⁸	2016	37	25 m	1 or 2 double loaded anchors	Blind	6.3%
Morsy et al. ²⁹	2017	51	31 m	2 double loaded	Blind	5.4%
P Domos et al. ³⁰	2017	20	26 m	One double loaded anchor	Blind	4%
P Domos et al. ³⁰	2017	20	26 m	One double loaded anchor	Blind	5%
Bonneyvialle et al. ³¹	2017	34	35 m	Two single loaded anchors	Blind	14.7%

labral tear is evaluated. The arm is removed from traction in order to perform a dynamic arthroscopic assessment. Shoulder is moved from neutral to external rotation at 45 and 90 degrees of abduction. If the Hill-Sachs lesion is seen to engage the anterior glenoid rim during this dynamic assessment, the decision is taken to carry out remplissage procedure. Strong indications for remplissage are preoperatively measured off track Hill-Sachs lesions and revision surgery.

Under direct vision and using outside in technique, an antero-inferior portal is made in the apex of the rotator interval, lateral to coracoid and above the subscapularis tendon. This is the primary working portal for repair of anterior labral tear.

A viewing anterosuperior portal is then made at the anterior margin of the acromion using outside in technique, entering the joint immediately behind the biceps tendon.

The arthroscope is then switched to anterosuperior portal. The extent of labral tear, anterior glenoid bone loss, extent and location of Hill-Sachs lesion are assessed.

Now, an accessory posterolateral portal is made about 1.5 cm–2 cm lateral to posterior viewing portal under direct vision using a spinal needle aiming at the centre of Hill-Sachs defect (Fig. 1).

A size 8 mm cannula is inserted through this portal. The surface of Hill-Sachs lesion is denuded of all cartilage using curette, shaver and burr in reverse mode until punctate bleeding is observed. This is an important step which will help in good healing of the capsule (Fig. 2).

Remplissage repair is akin to repair of partial articular surface tear of the rotator cuff, the aim here being fixation of the infraspinatus tendon and adjacent posterior capsule to the abraded surface of the Hill-Sachs lesion.

Number and nature of anchors used depends on the size of Hill-Sachs defect and quality of bone. Author's preference is double loaded anchor. One double loaded anchor is enough for a smaller defect. Two double loaded anchors would be needed for a larger defect (Fig. 5). If 2 anchors are used, the first anchor is placed in the inferior aspect of the Hill-Sachs lesion followed by the second one in the superior aspect. Bio-composite anchors would hold well in good bone. If the bone is weak and soft, 5 mm Titanium cuff anchor is inserted.

The location of the anchor is important. It should be adjacent (usually within 5 mm) from articular cartilage margin of the Hill-Sachs defect. This is in order to achieve the tenodesis effect. If it



Fig. 1. Hill Sach as viewed from posterior portal & anterosuperior portal. Needle points the direction of posterolateral portal.



Fig. 2. Preparation of Hill Sach lesion and insertion of anchor.



Fig. 3. Part withdrawal of cannula and placement of sutures.

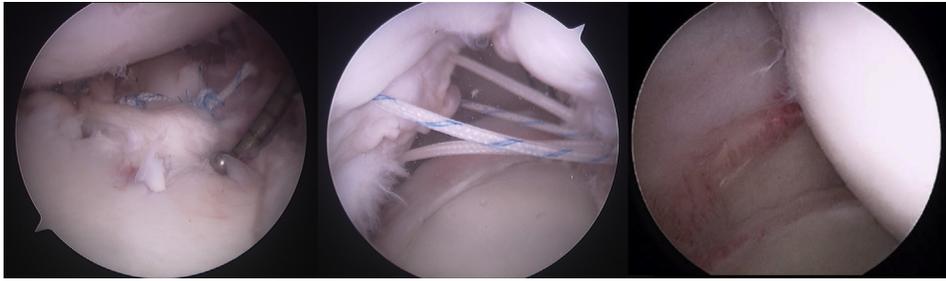


Fig. 4. Labral repair and Hill Sach Remplissage completed.



Fig. 5. Hill Sach repair with two double loaded anchors.

is located away from the articular margin, it is not likely to achieve the remplissage effect of tenodesis. If it is done too medial, it may cause limitation of internal rotation of humeral head. Attention should be taken to direct the anchor away from the articular surface to avoid joint penetration.

The cannula is now withdrawn in gradual fashion so that it lies just outside the capsule and infraspinatus muscle. At this level, a penetrating type of suture grasper is utilized to pierce just the infraspinatus muscle and posterior capsule in appropriate points to achieve cross or box mattress configuration using the two pre-loaded sutures (Fig. 3). Care should be taken to avoid taking bite into the muscular portion of infraspinatus as it may cause posterior shoulder pain.

If two anchors are used, the sutures from the inferior anchor is taken first. All sutures are placed in this fashion and left untied.

Through anteroinferior working portal, anterior labral repair is completed from inferior to superior direction with two to three all-suture or labral PEEK/Biocomposite anchors achieving inferior

capsular shift and recreating bumper effect of labrum.

Finally, the remplissage sutures are tied consecutively with the viewing scope still in anterosuperior portal providing an excellent view of the soft tissue reduction to Hill-Sachs defect (Fig. 4). Sutures are tied in a blind fashion over the infraspinatus muscle in the subdeltoid space using sliding knot. These sutures can also be visualised in the subacromial space and tied under direct vision. However, the author does not think it necessary as far as the cannula tip is correctly placed in the sub-deltoid level.

This procedure will convert the intra-articular Hill-Sachs lesion to stay extra-articular and also keep the humeral head centred over the glenoid (Fig. 6).

8. Post-operative rehabilitation

In author's practise, postoperative regime is similar to arthroscopic Bankart repair alone. Cold compression therapy is given for the first twelve hours. Active elbow and hand movements are

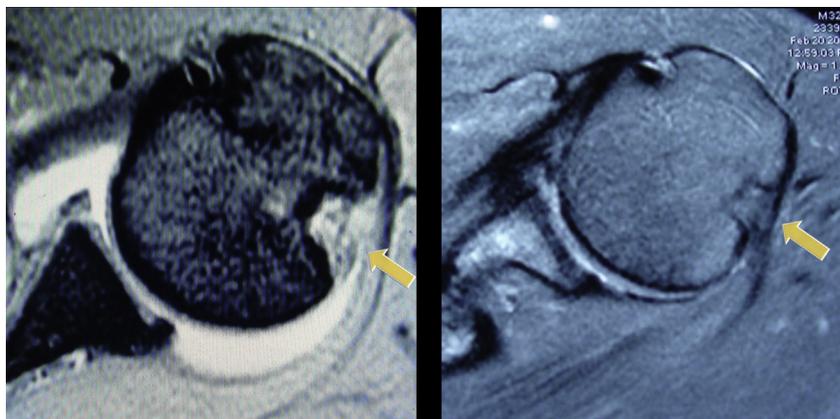


Fig. 6. MRI before and after remplissage.

started. From the second postoperative day, patient will start mobilizing the shoulder. These exercises include shoulder shrug, shoulder roll, pendulum movements and assisted arm elevation exercises up to 90°. Arm is rested in sling for four weeks.

From four weeks onwards, active assisted range of movement is begun, gradually progressing to full ROM. At the end of two months, shoulder muscle strengthening exercises are permitted. Patient is allowed to start sports training from six months onwards and full participation is allowed at 9 months to one year.

9. Order of remplissage and labral repair

There are two ways of remplissage. This is based on whether the surgeon decides to do remplissage from the start of the case.

If remplissage is decided early on, the best way is to place the remplissage anchor and sutures first and then tie at the end, after labral repair.

The steps are:

1. Diagnostic arthroscopy
2. Insertion of remplissage anchor in the appropriate location on the Hill-Sachs lesion.
3. Placement of the sutures in posterior capsule/infraspinatus tendon, but without tying them.
4. Completion of the anterior labral repair with 2–3 anchors, achieving inferior shift.
5. Tying the sutures of the remplissage.

There are some advantages with this technique. Clear visualization of Hill-Sachs defect and placement of anchor in the appropriate site on the humeral head. Also, more space is available to pass instruments to place the sutures in the appropriate points on the infraspinatus and capsule. In contrast, repairing the anterior labrum and re-tensioning of anterior capsule will tend to shift the humeral head backwards, thereby reducing 'working space' to perform remplissage posteriorly.

Remplissage anchor and sutures are placed, but left untied. If tied, it can result in less humeral head translation, thereby hampering access to anteroinferior labrum and IGHL. With remplissage sutures left untied, complete repair of the anterior labrum with its inferior shift is technically easy. Once the anterior labral repair is completed, it will automatically reduce the soft tissue to Hill-Sachs lesion.

In a case of borderline Hill-Sachs lesion, some surgeons may prefer to complete the anterior labral repair first and then take the arm into external rotation in abduction to check whether the Hill-Sachs lesion is engaging. If engaged, then one can proceed with remplissage. There is a small risk of damage to labral repair with this approach, as the repair is put to test immediately. Secondly, there is little working space for the insertion of remplissage anchors and sutures after anterior labral repair. Thirdly, forceful pushing and manipulation of the shoulder while inserting the Hill-Sachs suture anchor can disrupt the capsulolabral repair.

10. Two ways of knot tying

In remplissage knot tying, one should avoid catching any deltoid muscle fibres. This can cause pain on mobilization. There are two ways of achieving this.

10.1. Blind tying at subdeltoid level with intra articular view

Here, an accessory posterolateral portal is made and cannula is used to place the anchor and sutures. The cannula is withdrawn just enough to place the cannula tip outside the rotator cuff under the

deltoid, and the sutures are tied using sliding knots in a blind fashion.

Advantage: quick procedure, as this is done under intra-articular view from anterosuperior portal itself. No time is wasted in sub-acromial dissection to find the sutures.

Disadvantage: Chance of catching deltoid fibres if cannula is withdrawn more than the required level of depth.

10.2. Subacromial scopy and tying knots under vision

Remplissage anchors and sutures are placed. Labral repair is completed. The arthroscope is then placed in the subacromial space. The sutures are retrieved after clearing the subacromial space and then tied over the infraspinatus tendon under direct vision.

Advantage: Sutures tied under direct vision, so there is no chance of catching any deltoid fibres.

Disadvantage: Takes up additional time during surgery and added difficulty in locating the sutures in the subacromial space.

Another technique called 'Double Pulley' remplissage was described by Koo et al. where the sutures were tied sub-acromially.³³ Here, the subacromial space is cleared first. Through intra articular view, two trans-tendon suture anchors are placed in the Hill-Sachs lesion. Next, the previously placed Bankart repair sutures are tied, and finally the remplissage sutures are tied in the subacromial space over the infraspinatus by using the trans-tendon double-pulley technique. This technique uses the eyelets of the 2 suture anchors as pulleys and creates a double-mattress suture. The authors claimed a large footprint of fixation and direct visualization of knots in subacromial space as its advantages.

11. Advantages of arthroscopic Hill-Sachs remplissage

1. Simple arthroscopic technique, takes a little extra time to Bankart repair.
2. Local tissue advancement to fill in the Hill-Sachs defect, converting its location from intra articular to extra articular.
3. Keeps the humeral head centred over the glenoid, supports the anterior labral repair.
4. No significant loss of movement. Less than 10° difference in external rotation is hardly noticeable and hence has no impact on function.
5. No other significant complication has been reported.
6. Reduced recurrence rate following remplissage combined with Bankart repair when compared to arthroscopic Bankart repair alone.
7. Better functional score and lower risk of recurrence when compared with osteochondral substitute grafting

12. Disadvantages

Some patients may describe posterior shoulder pain due to capsular tenodesis, especially when the arm is taken into terminal external rotation. Care should be taken to avoid taking bite at the muscular portion of infraspinatus and catching any deltoid muscle fibres during knot tying.

13. Conclusions

Remplissage - the filling of the Hill-Sachs defect with infraspinatus and posterior capsule - is a reliable safe adjunct procedure to arthroscopic Bankart repair in cases of recurrent shoulder dislocation with large, engaging or off-track Hill-Sachs lesion and in revision instability surgery. It reduces the overall recurrence rate

and improves the functional outcome with excellently reported short to mid-term results.

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