Technical Note

Arthroscopic Remplissage Using Knotless, All-Suture Anchors

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Abstract: Glenohumeral bone loss is a significant risk factor for recurrent instability after shoulder dislocation. The Hill-Sachs lesion is an osseous defect of the posterior humeral head that is commonly recognized after anterior shoulder dislocation. Several procedures exist to address humeral-sided bone loss, including soft tissue filling procedures, osteoarticular allografts, bone plugs, rotation osteotomies, and humeral head replacements. However, among the most common of these procedures is the arthroscopic remplissage. This technique involves capsulotenodesis of the posterior shoulder capsule and infraspinatus tendon into a Hill-Sachs lesion. Previously described techniques use knotted suture anchors. In this report, we describe a modified technique for remplissage using knotless, all-suture anchors to perform capsulotenodesis of a Hill-Sachs lesion. Benefits of this technique include a single skin incision, improved bone preservation, and easier facilitation of revision surgery if required.

Introduction

The glenohumeral joint is the most commonly dislocated joint in the human body.[1] Shoulder instability can result in significant pain, disability, and clinically relevant bone loss about the joint. With each subsequent dislocation, the risk for glenoid and humeral bone loss increases.[2] Originally described in 1940,[3] the Hill Sachs lesion (HSL) describes bone loss on the humeral head. HSLs are a direct result of instability events and occur as the posterior superior aspect of the humeral head is impacted against the anterior glenoid rim during anterior dislocation. These forceful instability events with associated HSLs have been reported to involve up to 50% of the articular surface of the humeral head.[4] The prevalence of HSL following first time dislocation is up to 90%[5] and up to 100% among those with recurrent anterior dislocation.[6]

The majority of these lesions occur secondary to failure of the static restraints about the anterior shoulder, namely the anterior band of the inferior glenohumeral ligament (IGHL) and anteroinferior labrum (Bankart lesion).[6] Damage to anterior soft tissue structures is common in patients with HSL and often occurs concomitantly with bone loss of the anterior rim of the glenoid (bony Bankart).[7]

Determining the clinical significance of bone loss in the glenohumeral joint can be challenging. In general, patients that experience bone loss on both the humeral and glenoid side of the shoulder joint are at significant risk of recurrent instability and poor outcomes. Concomitant humeral and glenoid-sided bone loss is termed "bipolar" bone loss. Burkhart and De Beer originally described a phenomenon in which the humeral head defect (HSL) can engage with the glenoid bony defect (bony Bankart) leading to clinically relevant catching and instability.[8] They found patients with engaging bipolar bony defects during range of motion were nearly 17 times more likely to fail arthroscopic repair when compared to those without engaging bipolar bony defects (67% vs 4%, respectively).[8] From this landmark article arose an understanding of the relationship of bony defects in patients with bipolar bone loss and future instability events. Ideas, such as critical glenoid bone loss[7] and subcritical bone loss,[9] together with the "on-track, off-track" concept[10] helped establish

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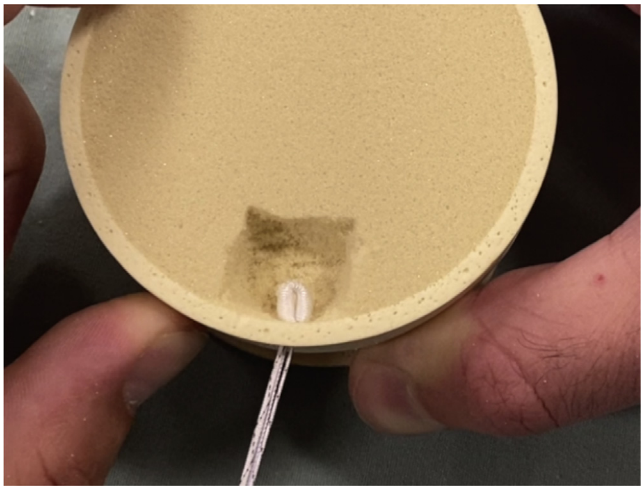

Fig 1. Arthrex FiberTak knotless, all-suture anchor. When tensioned, the sleeve is cinched up to compress against the cortical bone, creating a subcortical "ball", which serves as the anchor.

a reproducible method for quantifying bone loss. These factors help guide treatment decisions for patients with anterior instability, especially in the setting of bipolar bone loss.

Several methods exist to augment humeral sided bone loss in the setting of an engaging HSL or "off-track" shoulder with the intent of restoring native anatomy by filling in or offloading the humeral defect. Among these options are remplissage, osteoarticular allografts, bone plugs, disimpaction procedures, rotational osteotomies, and prosthetic humeral head replacement.[11] Outcomes for these procedures vary widely.[6,11] A widely used method for addressing humeral head defects is the arthroscopic remplissage procedure. Originally described by Purchase et al.,[12] and modified by Koo et al.,[13] the remplissage procedure involves capsulotenodesis of the posterior capsule and infraspinatus tendon into the HSL, thus converting the intraarticular defect into an extraarticular defect.

In this remplissage technique article, we describe a modification of the senior author's previously described double-pulley technique.[14] In our technique, we use 2.6 knotless, all-suture anchors (FiberTak, Arthrex, Naples, FL) to perform capsulotenodesis of a HSL. Knotless, all-suture anchors typically consist of a sleeve or tape made from suture woven with ultra-high molecular weight polyethylene. When the all-suture anchor is inserted into bone and tensioned, the sleeve is cinched up to compress against the undersurface of the cortical bone, thus creating a subcortical ball, which serves as the anchor[15] (Fig 1). Studies comparing soft, all-suture anchors with solid suture anchors have shown similar biomechanical properties.[16] Our described technique provides several advantages over other published techniques, including a single skin incision to shuttle sutures while filling the HSL, improved bone preservation, improved postoperative imaging, and possible facilitation of easier revision surgery if needed.[17,18]

Preoperative Decision Making

Standard preoperative shoulder radiographs with anteroposterior, internal rotation, and axillary views are obtained preoperatively. A magnetic resonance imaging scan is obtained to evaluate rotator cuff pathology and other intraarticular soft tissue/bony lesions, specifically glenoid bone loss and HSL size. Bipolar bone loss is determined to be either "on-track" or "off -track", as per the method described by Di Giacomo et al.[10]

Surgical Technique

After the induction of general anesthesia, an exam under anesthesia is performed in the supine position. The patient is then positioned in the lateral decubitus position on a beanbag with the use of a padded arm sleeve. A modified load and shift test is then performed in the lateral decubitus position to test the integrity of the IGHL. With the affected arm abducted to 90°, the examiner's contralateral hand is used to stabilize the

Fig 2. Demonstration of the modified load and shift test, performed in the lateral decubitus position. The arrow represents the antero-inferior force vector of the examiner's hand, while providing a scapular stabilizing force with the contralateral hand.

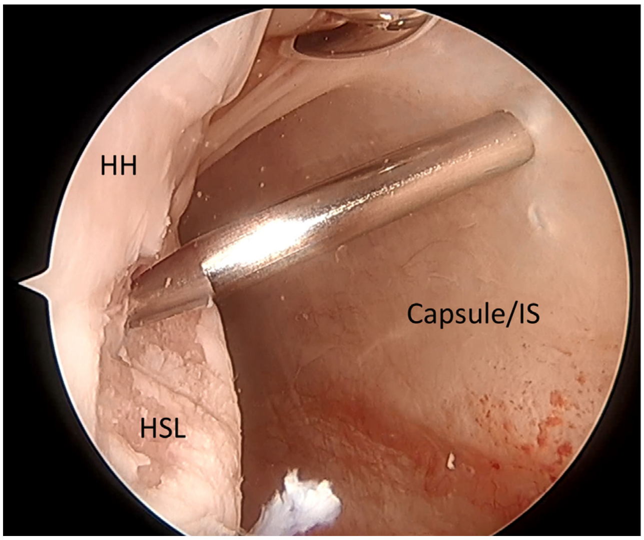

Fig 3. With the patient in the lateral decubitus position, viewing from the anterior portal a blunt, narrow switching stick is passed through the remplissage accessory portal and advanced through the rotator cuff resting at the terminal posterior aspect of the Hill-Sachs Lesion. HH, humeral head; HSL, Hill-Sachs Lesion, IS, infraspinatus tendon.

superior aspect of the scapula. An anterior inferior force is then placed on the affected extremity, and stability of the extremity is noted (Fig 2).

Standard portals are created through which the Bankart lesion will be addressed as per surgeon preference. A standard diagnostic arthroscopy is performed with the inspection of the glenoid to confirm a lack of significant glenoid bone loss. The HSL is inspected for size and position relative to the articular surface and posterior rotator cuff insertion. The arm is then taken dynamically into abduction and external rotation to check for engagement of the HSL over the anterior glenoid rim. Standard Bankart repair techniques are used to mobilize, biologically prepare, and repair the lesion. The Bankart repair may be delayed until after the remplissage is performed to ensure adequate visualization of the HSL as anterior shear forces on the humeral head required during remplissage anchor placement could theoretically stress a completed Bankart repair.

For better visualization of the HSL, the patient's arm is placed into increased abduction, and the arthroscope is switched to an anterior portal for viewing. The lesion is prepared biologically to optimize healing potential of the tissue into the defect. This is done using a 4-mm bone shaver, burr, or rasp. This is facilitated by viewing from an anterior portal and working the shaver or rasp from the traditional posterior viewing portal.

This technique is a modification from the senior authors original technique.[14] As all suture anchors are smaller, the single percutaneous skin/deltoid incision through which both anchors will pass down into the subacromial space is smaller. This prevents the need for subacromial retrieval of sutures. Through the single incision, both the terminal ends of the HSL defect must be accessible. Using a spinal needle for visualization a portal is established through the deltoid down into the subacromial space on top of the infraspinatus tendon. Care is taken not to violate the rotator cuff while placing a cannula. A skinny, blunt narrow switching stick is placed through the cannula. While viewing from the undersurface of the cuff within the joint itself, the switching stick indents the cuff on each terminal end of the HSL to ensure appropriate placement. Starting at the terminal posterior extent of the HSL, the blunt narrow switching stick is advanced through the rotator cuff (Fig 3). A drill guide is then advanced over this switching stick and placed at the posterior terminal aspect of the defect and drilled with a 1.8-mm drill. A 2.6-mm knotless, all-suture (Fibertak; Arthrex, Naples, FL) anchor is then placed into the terminal end of the HSL with the sutures exiting through the infraspinatus tendon (Fig 4), and then into the subacromial space, exiting through the cannula. Next, the blunt switching stick is again placed through the cannula and redirected to indent the cuff at the anterior terminal aspect of the HSL. Once this position is determined, the switching stick is passed bluntly through the infraspinatus tendon and docked into the anterior extent of the HSL, thus creating a second window through the infraspinatus tendon down onto the HSL. The process of anchor placement is repeated resulting in two anchors at the terminal margins of the HSL, with two separate passes through the rotator cuff/capsule (Fig 5). Although there are two rents in the infraspinatus/capsule, both

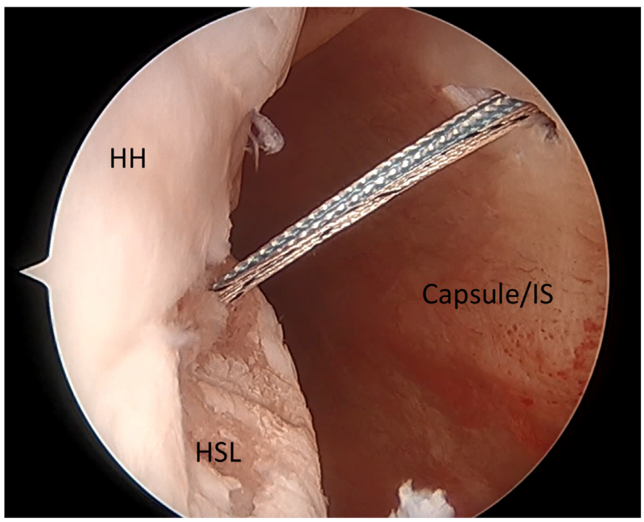

Fig 4. Patient in the lateral decubitus position, viewing from the anterior portal an all-suture anchor has been placed through the accessory remplissage portal into the terminal end of the HSL with sutures exiting through the capsulotendinous structures. HH, humeral head; HSL, Hill-Sachs lesion, IS, infraspinatus tendon.

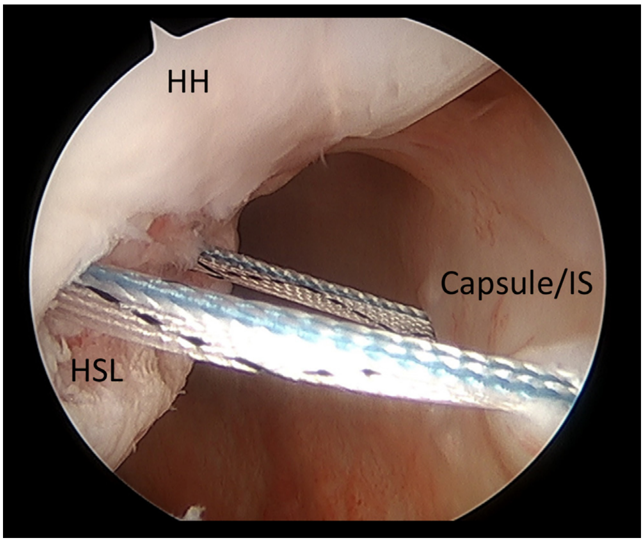

Fig 5. With the patient in the lateral decubitus position, viewing from the anterior portal, two knotless, all-suture (FiberTak; Arthrex, Naples, FL) suture anchors placed into the terminal ends of the HSL with the sutures exiting through the infraspinatus tendon, subacromial space and exiting through the single remplissage accessory portal. HH, humeral head; HSL, Hill-Sachs lesion, IS, infraspinatus tendon.

sets of sutures exit out from the same accessory remplissage portal.

Next the repair suture from the anterior anchor (anchor A) is passed through the looped end of the passing suture from the posterior anchor (anchor B). The nonlooped end of the passing suture from anchor B is then pulled to pass the repair suture. This step is repeated as the repair suture from the posterior anchor (anchor B) is passed though the looped end of the passing suture of the anterior anchor (anchor A). The nonlooped end of the passing suture from anchor A is then pulled to pass the repair suture (Fig 6). This leaves two repair sutures, which will be used to fasten the repair. Continued pulling on the free suture ends delivers the humeral head posteriorly into the capsule/infraspinatus, thus filling the HSL defect (Fig 7). This is shown in Video 1 as the suture tension is applied and the humeral head moves posteriorly, reducing against the rotator cuff tendon. Once additional intra-articular procedures are completed, the final remplissage reduction is secured by tensioning the repair sutures to the desired tension. Excess suture is then cut to complete the remplissage procedure.

Postoperative Protocol

Patients remain in a sling for 6 weeks. During this period of immobilization, Codman's pendulums are allowed together with passive motion under the direct supervision of a physical therapist. Weeks 1 through 3 allow for passive supine external rotation to 0° and forward elevation to 90°, with no internal rotation. Beginning at 4 weeks postoperatively, passive external rotation to 30° is allowed with progression to full forward elevation. At week 6, active motion is initiated with progression to full forward elevation and full external rotation by week 12. Internal rotation is allowed at this stage. At week 8, resisted exercises begin with seated rows, shoulder shrugs, bear hugs, and forward punch. At week 10, light weight training can begin, avoiding anterior capsular stress. Hands are kept within eyesight, and elbows are bent to avoid excessive force on the repair. Overhead activity is minimized at this stage. Patients are cleared for noncontact sports at 4 months. Patients are then cleared for contact sports at 6 months.

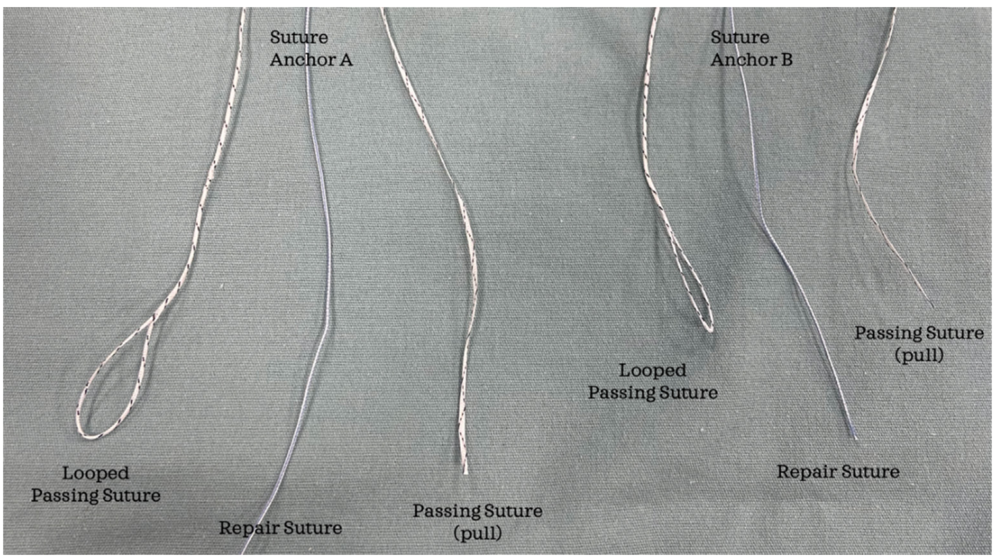

Fig 6. The repair suture from anchor A is passed through the looped passing suture of anchor B, and the passing suture of anchor B is pulled. Next, the repair suture of anchor B is passed through the looped passing suture of anchor A, and the passing suture of anchor A is pulled. Tension is placed on both of the remaining repair sutures to tension the repair.

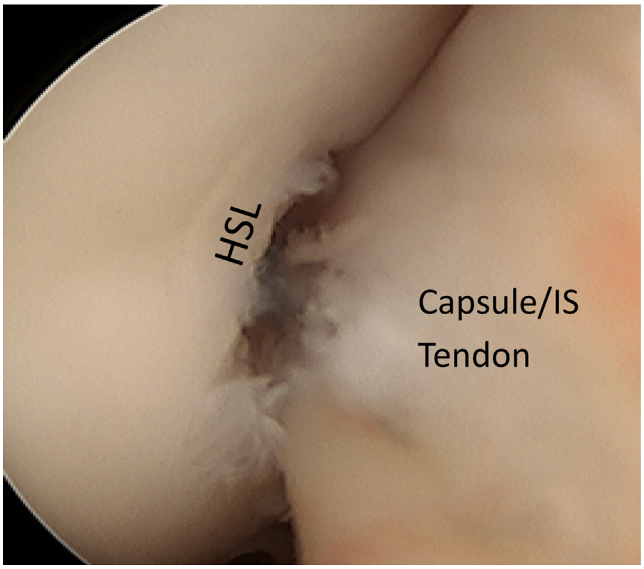

Fig 7. With the patient in the lateral decubitus position, viewing from the anterior portal, capsulotendinous tissue has been fixed down, thereby filling the Hill-Sachs Lesion. HSL, Hill-Sachs lesion, IS, infraspinatus tendon.

Discussion

This article outlines a step-by-step approach to perform a double-pulley remplissage with knotless, all-suture anchors (Fibertak, Arthrex). Originally described by Purchase et al.,[12] remplissage (French for "filling") was designed to fill the HSL with capsular/tendinous tissue to convert an intra-articular defect into an extra-articular defect.[12] Although there have been several technical modifications to this procedure described over the past decade,[12-14,17] outcomes of the remplissage procedure have repeatedly demonstrated high patient satisfaction and reported outcome measures at mid to long-term follow up.[19-21]

Pulatkan et al. evaluated different techniques for Hill-Sachs remplissage, as they relate to functional and radiological outcomes.[22] Their cohort study compared patients who underwent HSL remplissage using the double-pulley technique with two anchors versus those who underwent the procedure with a single anchor and mattress suture through the undersurface of the infraspinatus tendon. At an average follow up of 43.2 months, those in the double-pulley group demonstrated superior functional outcomes in terms of the Walch-Duplay score (91.0 ± 4.6 vs 86.3 ± 6.9), American Shoulder and Elbow Surgeons score (91.9 ± 3.7 vs 88.8 ± 3.2), and Filling Index Score of remplissage grade (6.8 ± 1.3 vs 5.8 ± 1.3). However, the mattress suture group demonstrated less restriction of external rotation at both neutral (9.0 ± 3.1 vs 11.9 ± 2.5) and 90° of abduction (8.0 ± 3.4 vs 11.0 ± 3.0). The authors concluded that both groups demonstrated favorable functional and radiological outcomes, but the double-pulley technique provided better filling of the lesion and improvement in functional scores when compared with the mattress suture technique.[22] The technique described in this article is a modification of the double-pulley method described by Koo et al.,[13] with several advantages. Advantages include the need for only a single skin incision to shuttle securing sutures and the use of knotless, all-suture anchors. These anchors have been demonstrated to allow for more bone preservation, to improve postoperative imaging, and to likely facilitate easier revision surgery if needed.[17,18]

Outcomes of arthroscopic Bankart repair with remplissage have been well studied. Gouveia et al. performed a systematic review to further investigate outcomes in arthroscopic Bankart repair with remplissage as compared to bone block augmentation in patients with anterior shoulder instability and bipolar bone loss.[23] The patients evaluated in this review had a subcritical glenoid bone loss defined as loss of less than 25% of glenoid width. The analysis included 145 articles with 7,984 shoulders and found bone block procedures to have significantly higher complication rates (0-66.7%) when compared to arthroscopic Bankart with remplissage (0-2.3%).

Additionally, complications in the bone block group tended to be more severe with nonunion, the most common complications being fracture, infection, and nerve injury. Both groups had similar postoperative functional outcomes and return to sport. It is worth

Table 1. Technique Pearls and Pitfalls

Pearls	Pitfalls
Use of a spinal needle to establish the accessory remplissage portal will assure access at both ends of the Hill Sachs defect through a single portal.	Ensure bone is of adequate quality to support suture anchor.
Use of a skinny switching stick during passage of cannulated drill will minimize damage to the rotator cuff.	Insertion angle of all suture anchor must be perpendicular to bone.
Use of a separate tensioning device prior to cutting access suture will assure adequate tension.	Ensure adequate length of passing suture through suture loop to avoid accidently unloading the anchor during pull through.
	Care must be taken to ensure adequate spacing between anchors at terminal ends of the HSL.

HSL, Hill-Sachs lesion.

Table 2. Technique Advantages and Disadvantages

Advantages	Disadvantages
Only a single skin incision is required to shuttle securing sutures.	Authors recommend against this technique in the revision setting.
All suture anchors allow for more bone preservation when compared to other suture anchors.	
All suture anchors require a smaller percutaneous incision through the cuff when compared to other more robust suture anchors.	

noting that in patients with 10-15% of mean glenoid bone loss, there was a mildly increased rate of recurrent instability with arthroscopic soft tissue repair and remplissage (6.1-13.2%) when compared to bony augmentation procedures (0-8.2%).[23] These results suggest that arthroscopic Bankart repair with remplissage may be indicated in patients with <10-15% of preoperative glenoid bone loss in the presence of an off-track or engaging Hill-Sachs lesion.

Similar results were found in a comparative study performed by Yang et al. They evaluated 189 patients, 91 who underwent a Laterjet procedure and 98 who underwent arthroscopic Bankart with remplissage. These procedures were performed in the setting of <25% glenoid bone loss and an off-track or engaging HSL. Yang et al. reported slightly higher SANE scores in the arthroscopic Bankart with Remplissage group (SANE 88.1) compared to the Laterjet group (SANE 85.3). Those who underwent arthroscopic Bankart and remplissage also had significantly fewer complications (1%) compared to the Laterjet group (12%). Similar to the systematic review by Gouveia,[23] Yang et al. found that patients with >15% bone loss had significantly higher rates of recurrent instability when treated with arthroscopic Bankart and remplissage when compared to Laterjet. (28.8% vs 6.06%; $P = .034$). Other studies have demonstrated subclinical decreased external rotation from the nonanatomic footprint of the infraspinatus post-procedure, in addition to increased pain scores in the immediate postoperative period.[24,25] Long-term studies have demonstrated that decreased external rotation and increased pain are not born out at long-term followup.[24]

This technique is a modification of the authors' previous technique.[14] The authors prefer this technique because the all-suture anchors do not require as large of a percutaneous incision through the cuff. The authors caution implementing this technique in the setting of >15% glenoid bone loss. We would also recommend against implementing this outlined technique in the revision setting after a failed arthroscopic Bankart repair (Table 1). Revision arthroscopic remplissage has demonstrated worse outcomes when compared to open revision procedures.[23,26-28] Most notably, McCabe et al. reported a higher failure rate in patients undergoing revision arthroscopic remplissage with lower overall improvement in functional scores when compared to remplissage with a primary stabilization (36% vs 0% failure respectively; $P = .01$; Table 2).[27]

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