Technical Note

The Subscapularis-Sparing "Flipped Latarjet" Procedure

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Abstract: The Latarjet procedure is a proven and effective operation to treat anterior shoulder instability. Especially in cases with anterior glenoid bone loss, the Latarjet operation is the most popular procedure to restore glenoid anatomy and avoid further dislocations. Next to the re-creation of the missing glenoid bone, the sling effect of the conjoint tendon transferred between a split in the subscapularis muscle is an important "soft tissue stabilizer" of the humeral head. However, it has been shown that the inferior part of the subscapularis muscle tends to degenerate, leading to fatty infiltration of the muscle itself. Also, exposure through the subscapularis split is technically demanding, and there is a risk of nerve damage due to the pulling forces of the retractors during open surgery. When performing the procedure arthroscopically, extremely low and medial portals are necessary to find a correct angle for the glenoid drilling when approaching from anterior. Neurovascular structures may be at risk during these surgical steps. The aim of the flipped Latarjet procedure is to facilitate a safe and reliable arthroscopic operation to anteriorly stabilize the shoulder by transferring the coracoid to the deficient glenoid without splitting the subscapularis muscle while keeping the benefits of a sling effect of the conjoined tendon.

Recurrent anterior shoulder dislocation is a challenging condition, leading frequently to bone deficiencies of the glenoid and humeral head. Different treatment concepts have been proposed to anteriorly stabilize the shoulder joint. Although soft tissue operations like the Bankart repair with or without a remplissage procedure may be an effective treatment option, bone loss cannot be restored.[1-4] Therefore, bone transfers were proposed decades ago to increase the glenoid's bony surface and restore the native anatomy.[5-8] Recently, the use of distal tibia allografts has been proposed to re-create the anterior bone stock of the glenoid.[9,10] Advantages of this concept are the avoidance of harvesting bone from somewhere else on the patient and the presence of cartilage on the donor site. Disadvantages are potential nonunions due to the limited blood supply and healing potential of the allograft and the limited or forbidden availability in some countries.[9] Traditional autograft techniques are the Eden-Hybinette procedure that requires bone harvested from the iliac crest or the Latarjet procedure, requiring an osteotomy of the coracoid process. Both techniques were traditionally performed in an open fashion, using screws for fixation. Screws provide excellent primary stability, but multiple complications may be related to hardware like inadequate screw angulation or lengthening, breakage, or incorrect placement.[11-13] Therefore, Hachem et al.[14-17] published a metal-free alternative for fixation of the coracoid by using a suture tape-cerclage technique.

Recently, the Latarjet operation and the iliac crest transfer have been done arthroscopically assisted or in a fully arthroscopic fashion.[8,18] Although the arthroscopic Latarjet procedure yields excellent visualization, it is technically demanding and the neurovascular structures may be at risk during surgery.[19]

An advantage of the extra-anatomic Latarjet procedure is the sling effect that has been described as an additional stabilizer, independent from the bone transfer.[20] Good clinical long-term results have been described for the Latarjet procedure, with redislocation rates of 3% after a 20 year.[21] However,

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potential complications of this operation are nonunions of the graft, graft breakage, osteolysis, hardware complications, and damage of the neurovascular structures.[11-13,19,21] Moreover, due to the permanent split of the subscapularis, weakness and muscle atrophy with fatty degeneration of the inferior part of the muscle itself have been described.[22,23]

The goal of the "flipped Latarjet" procedure is to combine all benefits of the Latarjet procedure while minimizing the risk for complications. Therefore, the flipped Latarjet procedure can be done fully arthroscopically, without interfering with the neurovascular structures, while keeping the sling effect.

Preoperative Assessment

Indications

Indications for this operation are patients with recurrent anterior shoulder dislocations and a minimum bone loss of 15% of the anterior glenoid measured on preoperative computed tomography (CT) "en face views." Detailed patient history with a description of the mechanism of dislocations and a profound clinical examination are mandatory. X-rays in at least 2 planes are necessary. The authors prefer to do a preoperative anterior-posterior view of the affected shoulder as well as a comparative Bernageau view to assess the bone deficiency on the anterior glenoid. Magnetic resonance imaging (MRI) scans are helpful to assess the capsule-labral complex and to estimate humeral and glenoid bone loss. CT scans are the method of choice if glenoid bone loss is to be measured exactly. Informed consent is obtained from every patient treated with this surgical technique.

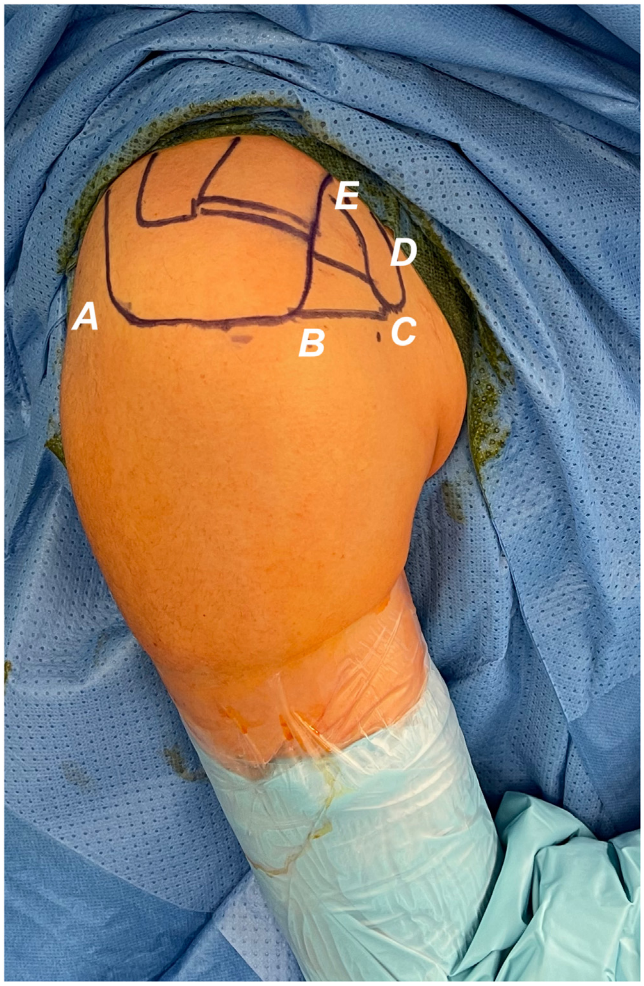

Fig 1. Lateral view on a right shoulder with marked arthroscopic portals: A = posterior viewing portal; B = anterolateral portal; C = anterior portal; D = deltopectoral portal; E = anterosuperior portal.

Surgical Video

Step 1: Patient Positioning, Anatomic Landmarks, and Diagnostic Arthroscopy

An intrascalene block is applied by the anesthesiologist before surgery. The patient is placed on a table in the beach-chair position under general anesthesia (Fig 1). Clinical examination of the joint is performed under anesthesia to confirm the anteroinferior instability. The following anatomic landmarks are defined and marked: scapular spine and acromion, acromio-clavicular joint and clavicle, coracoid process with coraco-acromial (CA) ligament, and pectoralis minor tendon. Five portals are needed for the operation (Fig 1).

A standard posterior viewing portal is created with a horizontal incision, and a 30° optic is introduced into the joint. Diagnostic arthroscopy is performed with special focus on the anatomy of the anterior glenoid and the Hill-Sachs lesion. Instability assessment of the Hill-Sachs lesion can be tested during dynamic examination. In case of comorbidities in the joint, the surgeon decides if they should be treated before or after the flipped Latarjet procedure.

Step 2: Bursectomy, Tendon Release, Preparation, and Drilling of the Anterior Glenoid

An anterior portal is created and a shaver is introduced. The rotator interval is completely resected, and a release of the upper part of subscapularis tendon is performed with the shaver and electrocautery. The subcoracoid bursa is fully resected, and the bursa subtendinea at the subscapularis muscle is partially removed from anterior. Care must be taken during the entire procedure to not damage the neurovascular structures, especially the axillary and musculocutaneous nerve. The lateral part of the conjoined tendon is released, and the tip and lateral border of the coracoid are identified (Fig 2). The CA ligament is detached from the coracoid using an electrocautery device. The remnant of the medial glenohumeral ligament is removed, as well as remnants of the capsule-labral complex. If the capsule-labral complex seems sufficient enough for subsequent reattachment, it can be preserved. An anterolateral portal is established parallel and slightly in front of the upper subscapularis tendon. A needle is used first to find the correct location. The scope is switched to this portal, and preparation of the anterior glenoid is performed by using a motorized burr through the anterior portal (Fig 3). The goal is to create a flush bone surface at the anterior glenoid that allows a flush contact of the coracoid graft later on. Electrocautery is used frequently to treat bleeding during the preparation. Next, the drill holes through the glenoid are made. Therefore, the posterior portal is increased in length horizontally for the introduction of the posterior drill guide (Arthrex). The guide provides the option to choose between a 5-mm and 7-mm anterior offset. The offset selected is determined after measuring the width of the coracoid, with the aim of drilling as centrally as possible. To be able to introduce the drill guide from posterior, the muscle fibers of the infraspinatus should be split in line with the fibers using a scissor. The guide is then introduced from posterior, and the spike at the tip of the guide hooks onto the rim of the anterior glenoid. The hook of the guide should be placed so that the drills exit at the 3-o'clock and 5-o'clock position in a right shoulder and at the 7-o'clock and 9-o'clock position in a left shoulder. The drill sleeve is then introduced through the drill guide handle and fixed in place. The sleeve must be in full contact with the posterior glenoid. Two 3-mm cannulated drills (Arthrex) are drilled from posterior to anterior through the scapula under direct visualization with the scope from the anterolateral portal (Figs 4 and 5). The subscapularis muscle and tendon can be retracted by using a switching stick coming from anterior to improve visualization. Internal rotation of the arm may be helpful as well. The nitinol wire loops are inserted through the cannulated drills and recovered anteriorly by a grasping device. The wires are replaced by FiberLink sutures (Arthrex), transporting both loop ends anteriorly. The suture limbs are taken out through the posterior portal and secured by a stump clamp.

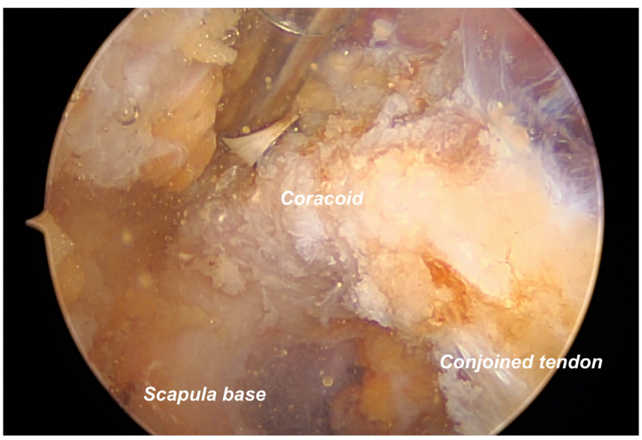

Fig 2. Arthroscopic view with a 30° scope from anterolateral showing an electrocautery device preparing the lateral aspect of the coracoid process.

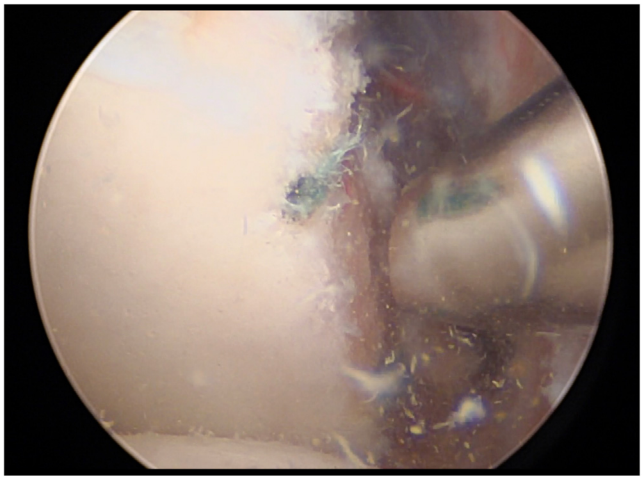

Fig 3. Anterolateral view of a preparation of the anterior glenoid with a 5.0-mm burr. Sutures from a previous Bankart repair are visible.

Step 3: Preparation and Osteotomy of the Coracoid Process

The undersurface and upper surface of the coracoid process are cleaned by electrocautery. A deltopectoral portal is created that allows direct visualization of the coracoid process from anterior. The camera is switched into this portal. A superior portal is made directly above the center of the coracoid process, and using electrocautery, the pectoralis minor tendon is released completely from the coracoid process. Care must be taken not to affect the musculocutaneous nerve and the axillary nerve, which are close to the medial aspect of the coracoid. Through the superior portal, a motorized burr is used to decorticate the superior surface of the coracoid process, starting from the tip toward the direction of the coraco-clavicular ligaments (Fig 6). The burr is switched to the anterolateral portal and used to create a stress riser at the base of the coracoid arch coming from underneath the coracoid. Then, the parallel drill guide is introduced through the superior portal. The guide is temporarily secured with an offset distance of 5 mm or 7 mm from the lateral border of the coracoid, depending on the offset that was used for the glenoid drills.

Two 3-mm cannulated drills are placed on the top of the coracoid process with the drill guide under direct visualization (Fig 7). The drills should be placed centrally on the coracoid process, and the drill guide should be tilted 15° to 20° toward the direction of the patient's

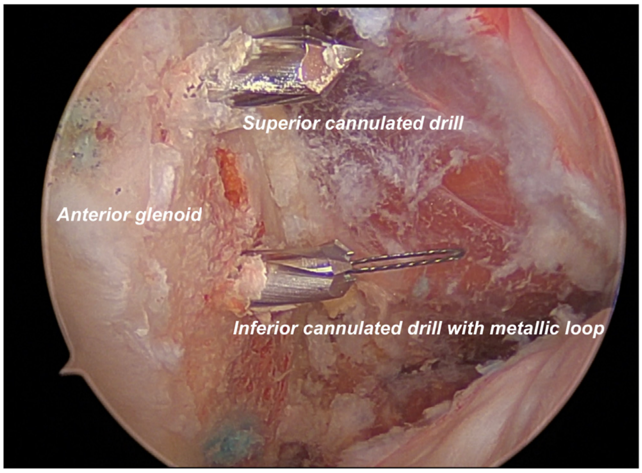

Fig 4. Anterolateral view showing the glenoid drilling with two 3.0-mm cannulated drills. A metallic loop was inserted into the inferior drill. The subscapularis muscle can be seen in the front.

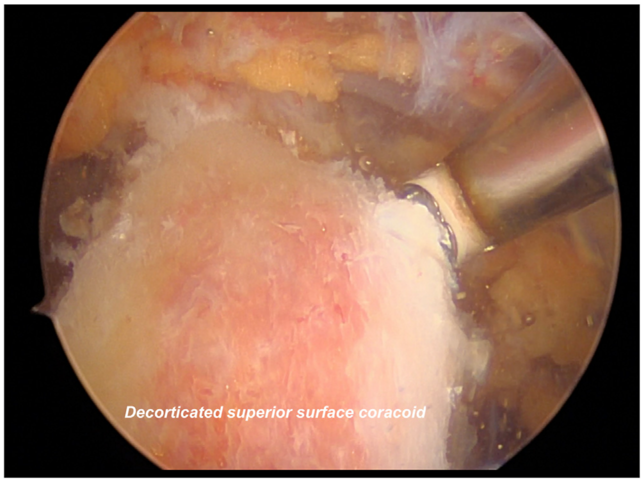

Fig 6. View from the deltopectoral portal showing an electrocautery device preparing the medial aspect of the coracoid. The pectoralis minor tendon is fully released. The superior surface of the coracoid process is decorticated.

head to get the correct angulation of the drill holes. A 1.1-mm K-wire is drilled through the cannulated 3.0-mm drill and through the coracoid to be sure the placement is correct. Once the placement is correct, the K-wires are then overdrilled with the 3.0-mm drills. The K-wires and drill guide are removed afterward, and nitinol wire loops are inserted through the cannulated drills and recovered through the anterior portal. The drills are then removed. After removal of the drill guide, it may be necessary for 1 assistant to close the superior portal by manual pressure using a sponge and finger to reduce outflow. The wires are replaced by stronger FiberLink suture loops (Arthrex), leaving the posterior coracoid drill hole suture loop superiorly and the anterior coracoid drill hole suture loop inferiorly. An additive plate supporting the undersurface of the coracoid can be placed before shuttling. Using the FiberLink loop superiorly, 2 FiberTape Cerclage sutures (Bone-Block-Cerclage; Arthrex) are passed through the posterior drill hole in the coracoid and out anteriorly. Using the other suture loop anteriorly, the same FiberTape Cerclage limbs are passed through the anterior coracoid drill hole superiorly. The 2 suture tapes are now passed through both drill holes, building a bridge at the undersurface of the coracoid. If a plate (3-hole straight plate made out of stainless steel; Arthrex) is

Fig 5. Outside view showing the surgical setup with the camera in the anterolateral portal, a switching stick in the antero-superior portal, and the posterior drill guide.

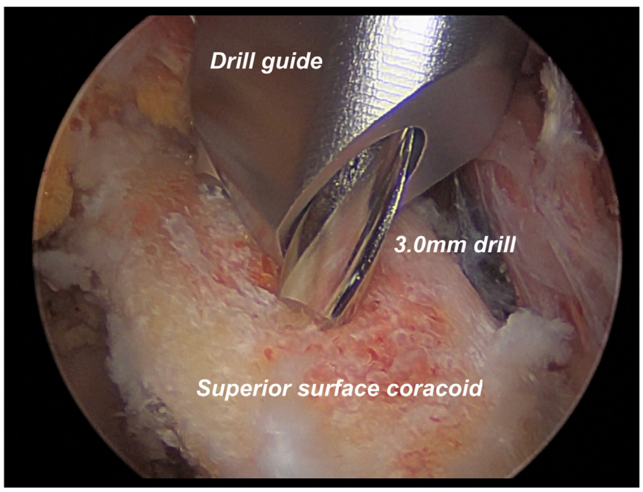

Fig 7. View from the deltopectoral portal showing the placement of the drill guide on top of the decorticated superior surface of the coracoid. Two 3.0-mm cannulated drills are placed through the drilling guide.

used, it can be seen lying at the undersurface of the coracoid protecting the bone bridge (Fig 8). All the limbs of the tape sutures are shuttled outside anteriorly. A cannula can be helpful. Then, the osteotomy of the coracoid is performed under direct visualization using a curved osteotome at the level where the stress riser was created earlier. After completing the osteotomy, the coracoid graft is mobilized and bone spurs at the scapula or the graft can be removed. By rotating the graft, the conjoined tendon is released and mobilized for the subsequent transfer.

Step 4: Shuttling the Cerclage

The FiberTape cerclage sutures that were previously placed through the coracoid are now shuttled through the glenoid from anterior to posterior. The tapes that are close to the tip of the coracoid are shuttled through the superior glenoid drill hole by using the previously placed FiberLinks, and the tapes close to the osteotomy are shuttled through the inferior drill hole. Care must be taken to not tangle the tapes. Once the tapes are shuttled out posteriorly, they should be secured with a clamp. The tape limbs and opposing color preconfigured racking hitch knots are then interconnected outside of the body posteriorly. The coracoid process must be completely mobilized and released as described above from any adhesions to make the flip and transfer to the glenoid possible.

Step 5: Flipping the Coracoid and Fixation of the Cerclage

The first assistant is managing the cerclage suture tapes standing posterior to the patient. The second assistant is holding the camera via the anterolateral portal. The surgeon is grasping the coracoid process with an arthroscopic clamp, while pushing the upper border of the subscapularis down and away from the glenoid by using a switching stick or a probe coming through the anterosuperior portal. The shoulder and elbow joint should be flexed slightly and internally rotated while doing the flip. The first assistant is lightly pulling on all the limbs of the tapes one by one, while the coracoid process is flipped over the subscapularis tendon (Fig 9). The upper and decorticated surface of the coracoid is pulled against the decorticated anterior glenoid. The coracoid is held in place while the first assistant is pulling in an alternate fashion on the 2 different-colored tapes, until the knots are introduced and firmly against the posterior surface of the scapula. The coracoid should be held in place by the surgeon with a clamp or probe. Care should be taken not to grasp the cerclage tapes. A tensioner is used to pretension the cerclage tapes and to make sure the knots are fully reduced (Fig 10). Then, a half-hitch is made over one of the cerclage tapes and a tensioner is used to apply compression until a force of around 100 N is reached. The tensioner is released, and additional half-hitches are applied (at least 3) and tightened. The authors usually place 5 half-hitches. The same process is done for the other cerclage suture tape. Correct and stable positioning of the graft is checked and any lateral overhand of the coracoid process into the joint must be avoided (Figs 11 and 12). In case of lateral overhand, the coracoid graft should be prepared with a burr until a flush position with the anterior glenoid is reached. In case of an intact capsule-labral complex, a Bankart repair using suture anchors can be added. The skin is closed with stitches and sterile plasters are applied. The arm is placed in a simple sling for immobilization.

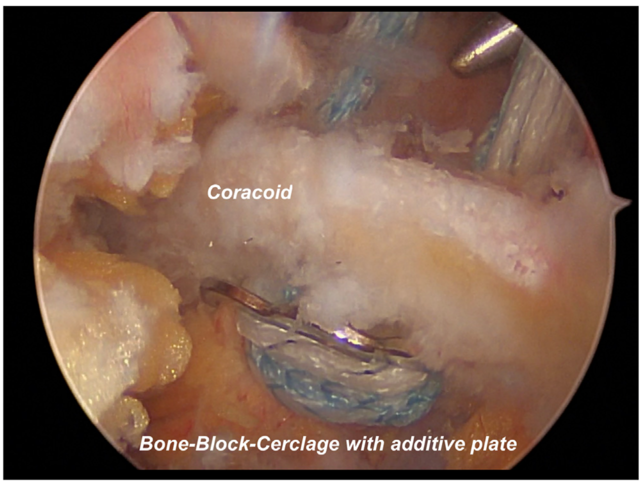

Fig 8. Anterolateral view showing the bone block cerclage shuttled through the drill holes in the coracoid process. The bridge of the cerclage lies at the undersurface of the coracoid. An additive plate is placed over the cerclage to protect the coracoid and to avoid a cutting through the cerclage.

Postoperative Care

Patients are immobilized in a sling for 4 weeks postoperatively. Radiographs in 2 planes are made after surgery, confirming correct placement of the graft. Passive range of motion is allowed, starting from postoperative day 1 with shoulder flexion and abduction to 30° and 0° of external rotation for the first 2 weeks. Passive flexion and abduction up to 60° and 20° of external rotation are allowed from weeks 3 to 4. Active-assistive flexion and abduction to 90° and free passive external and internal rotation are allowed from weeks 5 to 6. Free and active range of motion is allowed starting from week 7 postoperatively after an adequate radiographic control in 3 planes. Return to sports starts progressively after 3 months after a CT scan shows healing of the graft. Full weightbearing starts after 4 months.

Discussion

Several treatment options have been described for recurrent anterior instability of the glenohumeral joint.

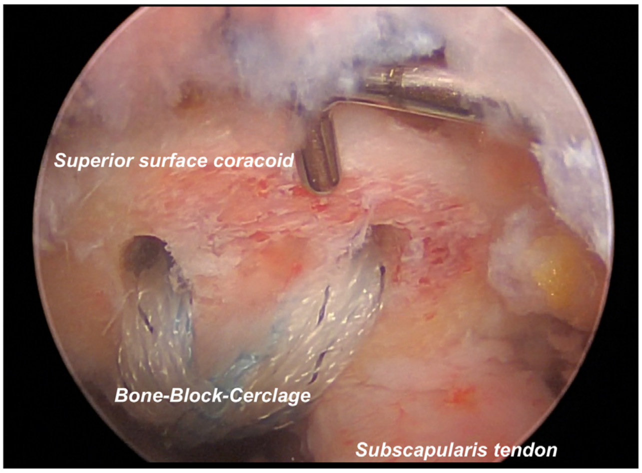

Fig 9. Anterolateral view showing the flipping process of the coracoid. The superior surface of the coracoid with drill holes and bone block cerclage is illustrated. A probe is used to flip the coracoid above the subscapularis tendon.

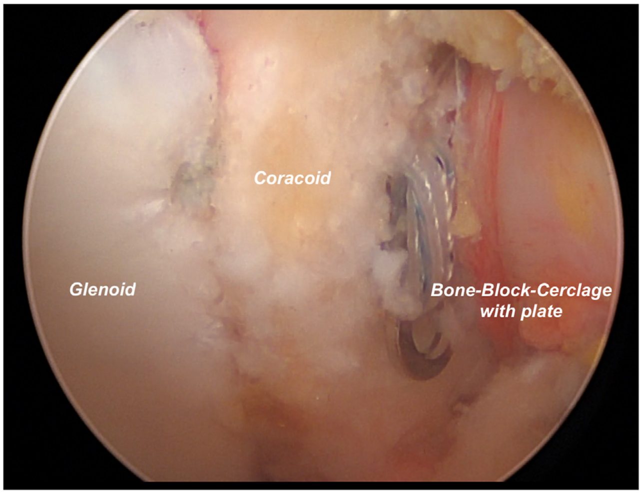

Fig 11. Anterolateral view of the final placement of the coracoid onto the glenoid with the tensioned bone block cerclage and additive plate. The bone block is flush with the anterior glenoid and no overhand was created.

Albert Trillat introduced a closing wedge osteotomy of the coracoid in the 1954, leading to a medialization and inferiorization of the coracoid.[6] The coracoid itself was fixed with a nail or screw into the scapula. The subscapularis muscle and tendon were lowered in its vector, creating an increased inferior stabilization of the joint. The arthroscopic technique of this procedure has recently been described.[24-26] The Latarjet procedure was a modification of the Trillat procedure that was initially described in 1954 by Michel Latarjet.[5] His concept worked well to anteriorly stabilize the joint and has been modified over the years, for instance, including the usage of 2 screws and a capsule repair with the stump of the CA ligament.[7] Laurent Lafosse was the first surgeon who published the surgical technique of a full arthroscopic Latarjet procedure in 2007,[27] followed by several surgeons adapting the technique. Due to the split of the subscapularis muscle, without detaching the tendon, a sling effect between the conjoined tendon and the inferior part of the subscapularis muscle is created and acts as an additional stabilizer next to the bone-grafting procedure.[20] Performing the operation through a subscapularis split makes the procedure technically demanding, both in an open as well as in an arthroscopic fashion. Siegert et al.[22] retrospectively compared the changes to the subscapularis muscle in patients who underwent an iliac crest bone graft to the anterior glenoid and patients who were treated with a Latarjet procedure. They found that the progress of fatty infiltration of the subscapularis muscle and the rerouting angle of the muscle were significantly higher for Latarjet patients on CT

Fig 10. Outside view showing the surgical setup during tensioning the cerclage. The first assistant is managing the tensioning device from posterior. The second assistant is flexing the shoulder and elbow slightly while internally rotating the arm. The surgeon is holding the camera while securing the flipped coracoid process at the anterior glenoid with a probe.

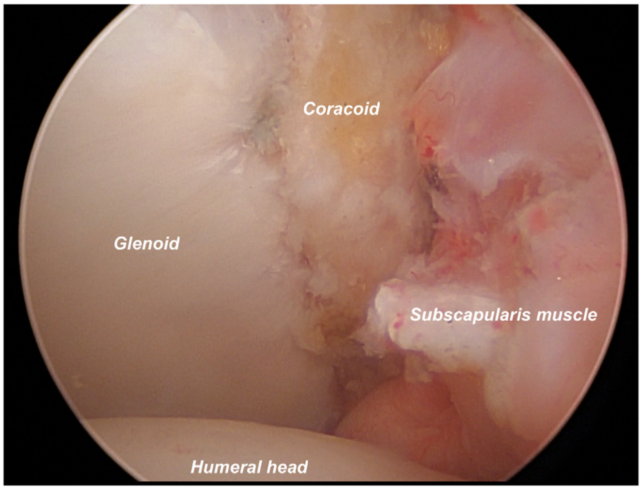

Fig 12. Anterolateral view showing the final placement of the coracoid onto the glenoid with the subscapularis muscle in the front.

scans, and this correlated with a lower capacity of internal rotation.

As the Latarjet procedure in general is a technically demanding operation, learning curves are relatively flat for open and arthroscopic techniques.[28-31] However, the learning curve for the arthroscopic technique itself has been described as steeper, and the operation is more time-consuming, leading to higher overall costs compared to the open technique.[28,29,31] Using the arthroscopic technique, a low and medial portal is necessary to reach the correct angle for screw placement, which may endanger the neurovascular structures. To avoid this problem, Boileau et al.[32] described an arthroscopic technique using suspensory fixation with suture buttons, with a drill guide coming from posterior. No neurologic complications were described by the authors since using the technique with a posterior drill guide. The benefit of suture buttons during the Latarjet procedure has also been described by other authors.[33,34] Recently, Hachem et al.[14-17] described a similar concept for the open and arthroscopic Latarjet fixation by using metal-free FiberTape Cerclage sutures. A posterior drill guide and a technique for tape shuttling was used as similarly described in the current publication. The authors concluded that the usage of a metal-free fixation may avoid hardware-related complications while providing adequate stability of the transferred coracoid graft. This can be seen as a potential advantage of the current technique (Tables 1 and 2) compared to the open and arthroscopic Latarjet procedure performed with screws. By using a posterior drill guide, the glenoid drilling can be done under full visualization and control without being at risk of damaging the neurovascular structures.

Although good clinical results have been described for the Latarjet procedure, complication rates vary between publications and have been reported as high as 30% of cases in the long run, with revision rates described in up to 7%.[11,12,19,35] One common finding is hardware-associated complications. Screw fixation yields excellent primary stability, but inadequate screw length may affect the suprascapular nerve posterior to the scapula. Due to the posterior drill guide, the placement of the drill holes through the glenoid is safe and system immanent, so an affection of the suprascapular nerve is uncommon. Inadequate screw placement may lead to damaging the cartilage, initiating glenohumeral osteoarthritis. Moreover, it has been described that the transferred bone to the glenoid adapts and shapes itself according to Wolff's law. Especially in the superior part,

Table 1. Tips, Pearls, and Pitfalls of the Technique

Tips and Pearls

- Complete resection of the rotator interval and the middle glenohumeral ligament is necessary.
- The subscapularis tendon and muscle should be released and the capsule should be taken out.
- Identification of the axillary nerve and musculocutaneous nerve is crucial.
- Measurement of the coracoid graft is crucial to avoid malpositioning.
- Identification of the coracoid landmarks is crucial for correct placement of drill holes.
- Placement of 1.1-mm K-wires through the coracoid process first is strongly recommended to control position of later drill holes.
- Start the osteotomy of the coracoid process laterally under full visualization and move medially. Time should be taken to do the osteotomy correctly and to avoid a fracture of the coracoid.
- A full release of the coracoid process and conjoined tendon is crucial for the flip afterward.
- Slight flexion of the shoulder and elbow with the arm in internal rotation helps during the flip maneuver.
- A metallic plate can support the undersurface of the coracoid and may avoid fractures.
- A tensioner is crucial to achieve adequate stability.

Pitfalls

- Inadequate release of the subscapularis muscle and tendon may lead to problems during the flipping maneuver.
- Nitinol wires may be too weak to shuttle the tape cerclage and can break. FiberLoops should be used.
- Shuttling the tapes through the glenoid should be done in the correct order by using a cannula and a tape grasper to avoid problems.
- Overtensioning of the tape cerclage may lead to a fracture of the coracoid, especially if a supportive plate is not used.

Table 2. Advantages and Disadvantages of the Technique

Advantages
- Procedure can be performed fully arthroscopically.
- Concomitant procedures (e.g., remplissage) can be done during arthroscopy.
- Neurovascular structures are not at risk during glenoid drilling as the drills are coming from posterior.
- The posterior drill guide allows safe and reproducible placement of the glenoid drill holes.
- Hardware complications can be avoided as no screws are used.
- Subscapularis muscle is not spilt, which may be of benefit.
- Sling effect is preserved as the conjoined tendon runs over the subscapularis tendon.
Disadvantages
- Inadequate release of the subscapularis muscle and tendon and/or coracoid process leads to difficulties during the flipping maneuver.
- Usually longer operative time compared to the classic open Latarjet procedure.
- Higher implant costs compared to the screw technique.
- No long-term data available.

resorption of the bone graft is common, resulting in prominent screw heads that may irritate the subscapularis muscle.[11-13,19]

The idea of the flipped Latarjet procedure was to find a surgical method that combines all benefits of the traditional Latarjet operation with the potential to avoid the abovementioned complications. The stated hardware-related problems are bypassed as a nonmetal tape cerclage technique can be used for this procedure. The risk for neurovascular injuries is minimized with the posterior drill guide, as no inferomedial portal is required for bone block fixation when using screws. A split of the subscapularis muscle is not necessary when using this technique, as the coracoid is flipped over the subscapularis muscle and tendon, while the sling effect is maintained or may be potentially stronger compared to the traditional Latarjet procedure as the whole conjoined tendon is running over the subscapularis muscle, which is lowered in its vector comparable to the Trillat procedure. In cases where a sufficient capsule-labral complex is present, a repair of the labrum can be done after the procedure using suture anchors. Care should be taken when drilling into the glenoid for the suture anchors, in order to not damage the cerclage suture construct. Potential weaknesses are a longer operative time with more surgical steps compared to the traditional open Latarjet operation with screws. Moreover, implant costs may be significantly higher compared to the screw method. Obviously, no long-term data are available to prove any superiority of the current method compared to the traditional open or arthroscopic Latarjet procedure.

Conclusions

The flipped Latarjet procedure is a new modification of the arthroscopic Latarjet operation with a subscapularis-sparing approach that can be done fully arthroscopically. The benefits of the Latarjet procedure (increasing the glenoid bone surface and sling effect) are kept, while reducing the risk of neurovascular damage, muscular deficiency, and hardware complications.

Disclosures

The authors report the following potential conflicts of interest or sources of funding: P.R. is a paid consultant for Arthrex. A.C. has a patent 11103292 issued to Arthrex. S.B. is employee of Arthrex. M.A. is employed at Arthrex GmbH. T.W. declares that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

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