Advanced Techniques in Shoulder Arthroscopy

Peter J. Millett
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Preface

"Education is more the kindling of a flame than the filling of a vessel"

– Socrates

This book is written for the benefit of all surgeons who have an interest in arthroscopic shoulder surgery. It is a compendium of different aspects of shoulder surgery that have been learned over the last 25 years. While there has been a rapid progression of shoulder surgery over the last two decades, particularly with the advancement of operative arthroscopic surgery, certain principles remain. The purpose of this book is not to be an exhaustive detailed account of the various historical aspects of arthroscopic shoulder surgery but rather an up-to-date, instructional handbook that outlines these principles. The book will also help the practicing shoulder surgeon become familiar of some of the latest techniques in arthroscopic shoulder surgery, demonstrating proven approaches and outlining key aspects of common and uncommon procedures. Each chapter starts with the indications for the procedure, moves toward the appropriate evaluation and diagnostic work-up, and culminates in specific technical explanation of the surgical procedure itself. We hope that this book will serve as a resource both for those who are new to arthroscopic shoulder surgery and for those who are skilled and experienced in operative arthroscopy. It is meant to provide a foundation for basic and advanced arthroscopic techniques that hopefully will help surgeons improve their craft and treat their patients better. Finally, for its readers, I hope that this book will "kindle the flame" of arthroscopic shoulder surgery.

I would also like to acknowledge the inspiration for this book, which has been mainly my fellows and students. These young men and women have not only helped in the development and refinement of many of the techniques but have also encouraged me to write this book. Moreover, I have had wonderful teachers – mentors, colleagues, and especially my patients. Through this book, I hope to share the knowledge and wisdom that I have learned over the last 25 years of arthroscopic shoulder surgery.

Vail, CO, USA
April 2018

Peter J. Millett, MD, MSc

This book is the culmination of advanced techniques in arthroscopic shoulder surgery that Peter J. Millett, MD, MSc, has pioneered and improved upon and is testament to his lifelong vocation to deliver the best patient care achievable. Not only his dedication toward the treatment of shoulder pathologies but also his passion for teaching these techniques to the next generation of surgeons is unparalleled, and I was honored to have the opportunity to learn from him over a year at The Steadman Clinic and Steadman Philippon Research Institute. This book seeks to further disseminate this knowledge and is a perfect manual for sports medicine orthopedic surgeons toward the completion of their training and even beyond.

As a coeditor, it is a unique privilege to be able to contribute to this book, and I believe I represent the dozens of fellows who have passed through Vail, CO, over the last 13 years to say that I am deeply grateful for the continued and enduring mentorship of Peter J. Millett, MD, MSc.

I also want to thank my German mentor Prof. Andreas B. Imhoff, MD, who was a strong advocate for my stay in Vail, CO. I am especially thankful for his unwavering endeavor to excel my clinical skills and knowledge and his guidance over the past years.

Munich, Germany Jonas Pogorzelski, MD, MHBA
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Part I

How to Start

1 Patient Positioning, Portals, Fluid Management, and Diagnostic Arthroscopy

Sandeep Mannava, Erik M. Fritz, Salvatore J. Frangiamore, Nicole Anderson, Burak Altintas, and Peter J. Millett

Introduction

The indications for arthroscopic shoulder surgery continue to expand. With advancements in surgical technique and surgical technology, more advanced arthroscopic procedures are now being performed routinely. Access to and visualization of the various anatomic structures and compartments of the shoulder joint is paramount to successfully performing shoulder arthroscopy. Proper patient positioning, portal placement, and fluid management aid in adequate exposure, minimizes complications, and facilitates efficiency during shoulder arthroscopy. The purpose of this chapter is to outline the authors' preferred techniques for patient positioning and portal placement. Additionally visualization of the various anatomic structures will be described through proper fluid management and basic diagnostic arthroscopy techniques.

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Anesthesia

The authors prefer the use of multimodal anesthesia, including an interscalene block, as it is shown to be useful in decreasing opioid consumption in the perioperative period during and following shoulder surgery.

Patient Positioning

Two positions are frequently utilized during both arthroscopic and open shoulder surgeries: beach chair and lateral decubitus. The authors prefer to use the beach chair positioning for the majority of shoulder procedures, while utilizing the lateral decubitus for the treatment of complex posterior and multi-directional shoulder instability.

Beach Chair

Operating Room Setup

In the beach chair position, the surgeon and assistants stand on the operative side, while the arthroscopy-viewing monitors are typically placed at the foot and at the head of the surgical table. The equipment tower is typically placed at the foot as well. The patient is normally seated after adequate anesthesia, with the operative extremity facing the surgeon. After sterile preparation and draping of the extremity, the Mayo stand and primary instrument table are brought toward the patient on the operative side.

Patient Positioning

The patient is positioned after induction of anesthesia, which can be either regional, general, or a combined regional and general anesthetic. The airway management devices are typically taped to the contralateral side. A foam ramp is placed under the patient's legs to ease tension on the lumbar spine, to pad the heels, and also to slightly flex the patient's knees and hips. The area under the ischial tuberosities is also well padded. An attempt is made to position the patient's greater trochanter at the break in the bed to lateralize the operative side toward the surgeon. Padded kidney supports are applied. Sequential compression devices are placed on both legs for deep vein thrombosis prophylaxis during surgery. Then, the patient's head is placed in a protective foam wrap that shields the eyes and keeps the head padded and secure. Occasionally foam goggles are used for ocular protection. Foley catheters are considered if the surgery may exceed 3 hours, and they should be secured to the patient in a visible location so that the anesthesiologist can monitor urine output. Routine shoulder procedures usually do not warrant Foley catheter placement.

The patient is brought into the beach chair position by flexing the torso into an upright position. Prior to sitting the patient upright, the surgeon should check with the anesthesiologist to ensure the patient has adequate circulatory perfusion and blood pressure, as sitting upright could result in transient hypotension resulting in cerebral hypoperfusion. The patient's head, neck, and torso are supported in the neutral position. Then, the head is carefully placed into the head positioner in neutral alignment. Positioning the head efficiently and safely usually requires two people: one for positioning the head in the neutral position and the other for securing the head to the operating table in the headrest. After the head is firmly locked, the anesthesiologist must ensure the airway is patent, secure, and accessible. The chin and other portions of the head should be well padded, and the neck should have a neutral alignment.

A seat belt is placed over the patient's legs with adequate padding to secure the patient to the bed. A warming device is then placed below the patient's nipples and over the patient's body to keep the patient adequately warm during the procedure. Care should be taken to ensure there is no pressure on the peroneal nerve region. The contralateral arm is positioned into a well-padded arm holder while keeping the elbow slightly flexed and the ulnar nerve floating free.

The back portion of the table is then shifted toward the contralateral side to provide access to the posterior shoulder throughout the case. The body is further secured with a well-padded "kidney" rest. Bringing the shoulder and the body lateral, or toward the operative extremity, helps facilitate intraoperative maneuvering of arthroscopic instruments, especially posteriorly. Air-planning the bed toward the contralateral side may also help facilitate access to the shoulder. The final patient position before draping can be seen in Fig. 1.1.

Fig. 1.1 Beach chair positioning: final patient position before draping. The patient is brought into the beach chair position by flexing the torso into an upright position. The patient's head, neck, and torso are supported in the neutral position. Then, the head is carefully placed into the head positioner in neutral alignment

After the patient is seated, hypotensive anesthesia can be induced. The surgeons should coordinate with the anesthesiologist to ensure the patient has a mean arterial pressure (MAP) between 80 and 100 mmHg. Arterial pressure must be monitored closely as increased MAP can hinder surgical visualization by leading to excessive bleeding, while hypoperfusion may compromise cerebral blood flow and lead to an ischemic stroke.

Sterile Preparation and Draping

A non-sterile assistant holds the forearm of the operative arm, while the surgeon cleans the skin on the hand and distal forearm with chlorhexidine solution. The surgeon then grasps the arm with a sterile stockinette. An assistant helps use additional preparation sticks in order to sterilize and cleanse the remainder of the forearm, arm, chest, neck, back, and finally the axilla. Care is taken to prepare a sterile field large enough for surgical intervention. Further, it is important to ensure that the axilla sterile preparation is performed last and that the skin flora from the axilla is not brought onto the remainder of the sterile preparation.

Three half sheets are utilized to cover the patient's legs, the patient's head, and behind the patients medial border of the scapula. These three sheets are secured anteriorly with a non-penetrating clamp. A shoulder-specific arthroscopy drape is placed over the top of

Fig. 1.2 Three half sheets are utilized to cover the patient's legs, the patient's head, and behind the patients' medial border of the scapula. These three sheets are secured anteriorly with a non-penetrating clamp. A shoulder-specific arthroscopy drape is placed over the top of the previously placed half sheets. The arm is then secured to a pneumatic limb positioning device with adhesive wrap

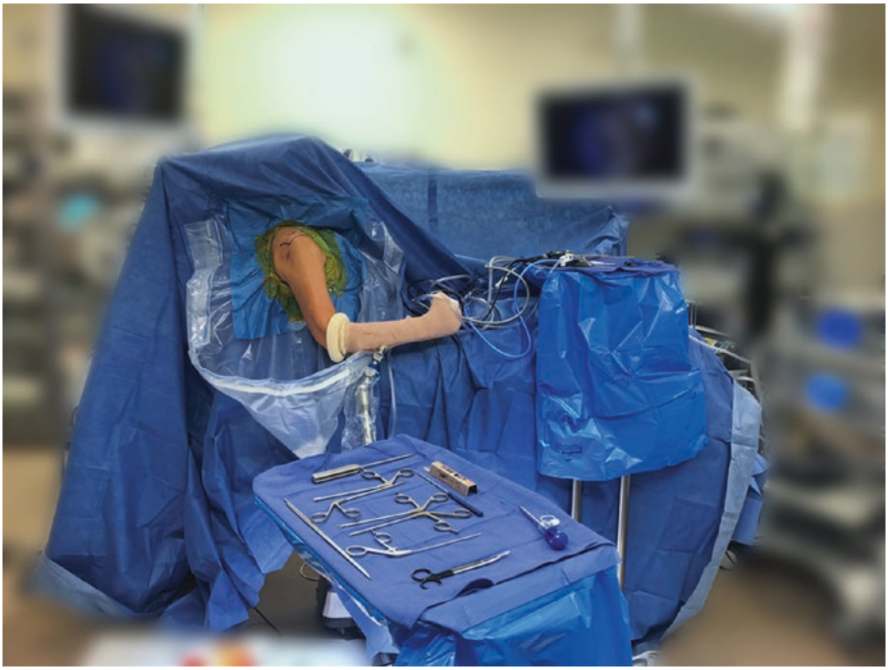

Fig. 1.3 Final setup after draping. All instruments are passed and checked to ensure that all are working. Finally, a time-out is undertaken prior to any surgical intervention to ensure patient safety

the previously placed half sheets. The arm is then secured to a pneumatic limb positioning device with Coban adhesive wrap. Many commercially available positioning devices also come with padded, sterile straps that can facilitate securing the arm to the positioning device. The opening of the drape around the shoulder is held medially by an assistant and then secured 360° around the shoulder using Ioban adhesive cut into strips to form sterile tape (Fig. 1.2). The instruments are then passed and checked to ensure that all are working. A time-out is then undertaken prior to any surgical intervention to ensure patient safety. The final setup after draping can be visualized in Fig. 1.3.

Lateral Decubitus

Operating Room Setup

Some of the earlier considerations discussed in this chapter with regard to anesthesia also apply for the lateral decubitus position. In the lateral decubitus position, the surgeon and assistants stand on the side facing the patient, while the arthroscopy tower is placed on the contralateral side. After sterile preparation and draping of the extremity, the Mayo stand and primary instrument table are brought toward the patient on the surgeon's side.

Fig. 1.4 The patient is turned onto the nonoperative side, so that the operative side is upward. The bean bag is then brought up both sides of the patient and deflated using suction

Patient Positioning

For this position, the patient is turned lateral onto the nonoperative side, so that the operative side is upward. Care is taken not to compress the nonoperative arm. Towels or foam pads are used under the head to prevent strain on the cervical spine and head. An axillary roll is placed beneath the axilla to avoid compression on the brachial plexus during surgery. Padding, such as pillows and foam, is placed beneath and between the legs to pad bony prominences and "float" the peroneal nerves. Slightly flexing the down leg while keeping the upper leg straighter helps to provide balance, avoid excessive pressure, and maintain the lateral position. The bean bag is then brought up both sides of the patient and deflated using suction (Fig. 1.4). Then, the genitals, areolas, and bony prominences are checked to ensure they are not subject to undue pressure throughout the case.

The contralateral arm is moved laterally onto a padded arm board to facilitate access during the procedure for anesthesia and can be held in place with several padded straps. A padded seat belt or sometimes additional tape placed over foam padding is utilized to secure the patient. For further stabilization, additional padding can be used as needed. Finally, the suspensory system and the pulley system are prepared (Fig. 1.5).

Sterile Preparation and Draping

The procedure for sterilization and draping of the forearm, arm, chest, neck, back, and axilla in the lateral decubitus position is similar to the beach chair position. Once sterilization is completed, the arm is attached to the suspensory system, and the pulley system is loaded with weight to maintain shoulder distraction in abduction (Fig. 1.6).

Fig. 1.5 A padded seatbelt or sometimes additional tape placed over foam padding is utilized to secure the patient. Additionally, the suspensory system and the pulley system are prepared

Fig. 1.6 Once sterilization is completed, the arm is attached to the suspensory system, and the pulley system is loaded with weight to maintain shoulder distraction in abduction

Fig. 1.7 It is recommended to mark the anatomic landmarks prior to the start of the surgery

The authors prefer about 70° of abduction for instability cases and lower levels of abduction for cases that involve repair of the rotator cuff. The amount of weight utilized for traction is based upon surgeon preference and patient body habitus. As a general guideline, 10–12 lbs of traction is used for women, and 12–15 lbs of traction is used for men. It is recommended to mark the anatomic landmarks prior to the start of the surgery (Fig. 1.7). The shoulder undergoes sterile preparation of the shoulder, arm and forearm, with the axilla being prepared last. Then a series of down drapes, followed by split drapes and then arthroscopy specific split drapes with a fluid collection system are utilized and secured by Ioban circumfrentially. The non sterile portion of the suspensory system is covered circumfrentially with a sterile drape as well.

Arm Positioners and Traction Devices

Beach Chair

For the beach chair position, the assistant can hold the arm during the surgery for variation in rotation, abduction, and flexion. The authors prefer using a pneumatic arm holder as it enables easy manipulation of the arm position by the surgeon.

Lateral Decubitus

In the lateral decubitus position, the arm can be pulled simply in line or by a balanced suspension device.

For both positions, axillary bumps or gentle traction by the assistant can be utilized to ease the procedure in creating a larger glenohumeral space.

Establishment of Portals

General Principles

1. Spinal needles are always used to test the trajectory of portals before they are created.
2. Portals should be at 90° to each other as much as possible to facilitate visualization and instrumentation.
3. Portal should be small or should have a cannula in them to prevent fluid loss and turbulent flow.
4. Intra-articular work will require cannulae.
5. Subacromial work can be done either through a cannula or percutaneously.
6. When tying or retrieving sutures, it is preferable to do so through a cannula.
7. If both sutures are retrieved at the same time through a percutaneous portal without a cannula, soft tissue bridges can be avoided.

The first established arthroscopic portal is the standard posterior portal. This portal is typically placed approximately 2 cm inferior and 2 cm posterior to the posterolateral acromion edge (Illustration 1). This portal may be slightly more lateral when the patient is positioned in the lateral decubitus position, as joint distraction could result in the joint being slightly more lateral than when the patient is positioned in the beach chair position. Prior to incision, the joint line can be palpated to confirm proper location. The authors prefer to use a spinal needle to determine the appropriate trajectory. If there is a large rotator cuff tear, the incision should be positioned slightly medial and inferior to aid in using suture shuttling devices and to allow access to the subacromial space. If the primary purpose of the procedure is a superior labral repair, the incision should be positioned slightly lateral, in order to improve the angle of the instruments and viewing for work on the superior labrum. When working anteriorly, a mid-joint portal is helpful.

After making a skin incision, the scope trocar with the blunt obturator is then placed into the joint. Palpation of the glenoid and the humeral head with the trocar should be done before entering the joint so as to enter the capsule in its midpoint and to avoid iatrogenic damage to the articular surfaces. The trajectory is aimed toward the coracoid anteriorly. Then the arthroscope is placed into the cannula to confirm intra-articular positioning. If the joint is difficult to enter, fluoroscopy can be used in rare cases to ensure the proper trajectory.

Diagnostic arthroscopy can be performed with the arthroscope in the standard posterior viewing portal. The second portal is the anterior portal. This portal is established in the rotator interval, between the upper border of the subscapularis and the anterior edge of the supraspinatus (Fig. 1.8). This portal is created by first confirming the location and trajectory with a spinal needle in an outside-in fashion. Following skin incision, a cannula is placed into the rotator interval. The authors prefer to use a small 5 mm cannula as this is more easily inserted and can be

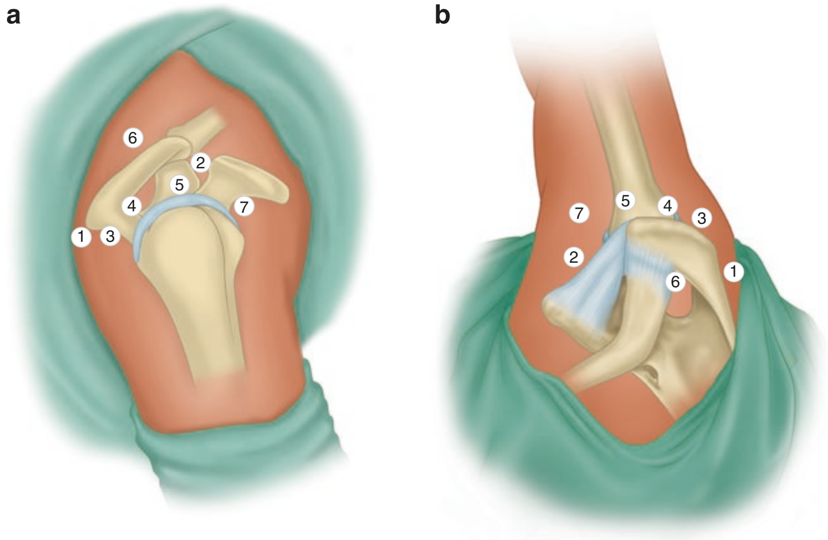

Fig. 1.8 Illustration showing the standard portals used in a right shoulder for advanced shoulder surgery in the beach chair (**a**) and lateral decubitus (**b**) position. 1 = posterior standard viewing portal; 2 = anterosuperior standard working portal; 3 = posterolateral working portal; 4 = lateral working portal; 5 = anterolateral working portal; 6 = Neviaser portal; 7 = anteroinferior working portal

repositioned without consequence if the position is not ideal. The position of the anterior portal is particularly crucial for anterior labrum repair as two anterior portals are needed. These two portals should be at 90° to each other. For this, the anterosuperior portal must be placed close to the acromion at the anterosuperior border of the rotator interval. This placement will ensure there is sufficient space for the anteroinferior portal, which is placed close to the superior subscapularis border. Correct placement will allow two working cannulas to fit into the rotator interval, which will facilitate efficient passing of sutures and instruments.

Further accessory portals are often established for access to various aspects of the glenohumeral joint (Fig. 1.8). Accessory portals are made by first establishing the trajectory with a spinal needle and then following that path with the cannula and trochar after skin incision. An anterolateral portal can be made through the lateral aspect of the rotator interval to access a SLAP tear. A trans-rotator cuff portal can be made to access the posterosuperior labrum. The size of the cannula or incision through the rotator cuff should be limited and made in-line with the fibers of the tendon or muscle belly, and it should be made more medially. A Neviaser portal may be created medial to the junction between the acromion and the clavicle to allow access to the superior labrum or glenoid. The low-anterior trans-subscapularis portal (or 5 o'clock portal) and the low-posterior portal (or 7 o'clock portal) can be made to allow access to the anteroinferior and posteroinferior glenoid, respectively. The low-anterior portal can put the musculocutaneous nerve and the cephalic vein at risk, while the low-posterior portal may result in axillary nerve damage. To avoid iatrogenic injury to neurovascular structures, care should be taken during portal establishment to only incision the skin, then serially dialate the portal to larger and larger sizes over a guidewire, prior to placement of the final cannula.

After completion of glenohumeral arthroscopy and related procedures, attention is often turned to the subacromial space. The arthroscope is removed from the glenohumeral joint, and the trocar is repositioned, sliding from the posterior acromion into the subacromial space. It should be noted that the orientation of the acromion slopes posteroinferior and in some cases the acromion slopes laterally as well. Upon entering this space, a spinal needle can be utilized laterally to help establish a lateral portal. This portal can be made anywhere along the lateral aspect of the acromion, although the authors prefer to make it anteriorly with the needle and subsequent portal coming in just posterior to the coracoacromial ligament. Placing it anterior allows for additional working portals to access the subacromial space at 90° using a posterolateral portal if needed. It also allows visualization of the AC joint should that be needed. After the skin is incised, a blunt trocar is inserted to make a track through which arthroscopic instruments can be exchanged into the subacromial space. If the rotator cuff has a large tear and repair is expected, creating two lateral portals, one anterior and one posterior to this midpoint of the acromion, is essential. to facilitate visualization, instrumentation, and subsequent repair.

A combination of a radio-frequency device and an arthroscopic shaver should be utilized to help with visualization in the subacromial space. Care should be taken not to violate the deltoid fascia, as this may result in the shoulder swelling excessively or the space collapsing because of inadequate containment of the arthroscopic fluid. The anterior or anterosuperior portal can also be used to enter the subacromial space through the same skin incision. This portal is typically useful for distal clavicle resection. Bursal resection should begin laterally as there is less vascularity and then can extend more medially.

Arthroscopic Fluid Management

Fluid management during shoulder arthroscopy is important to allow appropriate visualization throughout the procedure and to maintain hemostasis. The basic principal of fluid management is that arthroscopy fluid pressure should exceed capillary pressure. This can be accomplished by increasing the pressure of the arthroscopy fluid by gravity or by the use of an arthroscopic pump whose pressure can be varied and controlled. Also the use of controlled hypotension can be helpful. Although the use of hypotension can be beneficial, special attention must be taken to maintain adequate cerebral perfusion pressure throughout the case. While some have suggested that addition of epinephrine into the arthroscopic fluid may also aid in visualization by resulting in pharmacological constriction of the vasculature, the authors do not typically use it as it does not seem to make substantial differences in visualization and it avoids the risk of hypertension or tachycardia from systemic absorption of the medication.

While establishment of sufficient pressure is crucial for visualization, excessive pressure may result in fluid extravasation and excessive soft tissue swelling, leading to impaired visualization and iatrogenic injury. As a general rule, adequate visualization of the anatomic structures within the glenohumeral joint typically requires less pump pressure than the subacromial space. If there is excessive bleeding or difficulty with visualization, decreasing MAP, diluting the bleeding by increasing flow, or increasing the pump pressure can all help. To prevent excessive fluid extravasation, time spent using higher pump pressures should be kept to a minimum. Turbulent flow associated with egress of the fluid from non-cannulated portals should also be avoided. This can be established by the use of cannulas following progressive dilation.

Two common methods of establishing pressure are either with gravity suspension of the arthroscopic fluid bags or with a pump. Gravity flow is a reliable method, and there are several commercially available hangers that allow for precise measurement of the bag height off the ground. An increase in pressure can be achieved by hanging the bags higher or using tubing that allows for 2–4 bags to be opened at once.

An arthroscopic pump can also maintain the arthroscopic fluid pressure throughout the procedure. In theory, a pump may reduce the amount of arthroscopic fluid being used and can better titrate the exact pressure output. Commercially available pumps can either have an inflow-only option (acting as a simple pump), or they can have an inflow and outflow closed-loop system, which attempts to control inflow pump pressure based upon the current pressure in the joint space. Typically, a pump pressure of 30–40 mmHg is adequate for glenohumeral joint arthroscopy, and a pressure of 50–60 mmHg is sufficient for the subacromial space. Again, these pressures can vary based upon the pump being utilized. The principal of having lower pump pressure to maintain visualization should be followed during arthroscopy to reduce the chance of excessive fluid extravasation.

Diagnostic Shoulder Arthroscopy

Diagnostic shoulder arthroscopy is essential to adequately visualize and assess both normal and pathologic anatomy within the shoulder joint. A systematic approach will facilitate adequate assessment of pathology. If there is difficulty visualizing structures, establishment of the anterior portal will help. The authors prefer to start with the assessment of the anterior structures. A probe inserted through the anterior portal can be used to assess the integrity of the anterosuperior labrum and the humeral insertion of the subscapularis (Fig. 1.9). Also, the probe can retrieve the extraarticular portion of the long head of the biceps tendon by applying superior pressure; thereby pulling the tendon into the glenohumeral joint, and then the tendon can be assessed for tears, tenosynovitis, and pulley pathology (Figs. 1.10, 1.11, and 1.12). Care is taken not to slip out of the joint or damage the glenohumeral joint cartilage by levering excessively on the humeral head. Lateral distraction of the humeral head can help with visualization in the glenohumeral joint. The glenohumeral joint cartilage is evaluated for chondromalacia, and, if present, the grade and estimation of the area should be determined.

Next, the humeral insertion of the posterosuperior rotator cuff is examined for a complete or partial articular rotator cuff tear (Figs. 1.13 and 1.14). As the arthroscope is retrieved posteriorly, the humeral head can be evaluated for a Hill-Sachs

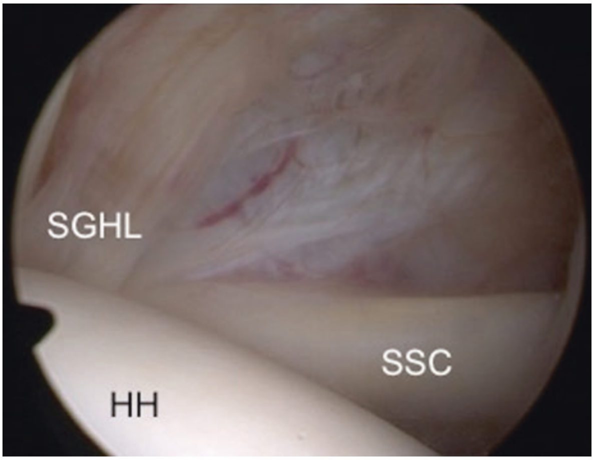

Fig. 1.9 Arthroscopic view from posterior of a left-sided shoulder. The diagnostic shoulder arthroscopy generally starts with the inspection of the subscapularis tendon. SSC, subscapularis tendon; HH, humeral head; SGHL, superior glenohumeral ligament

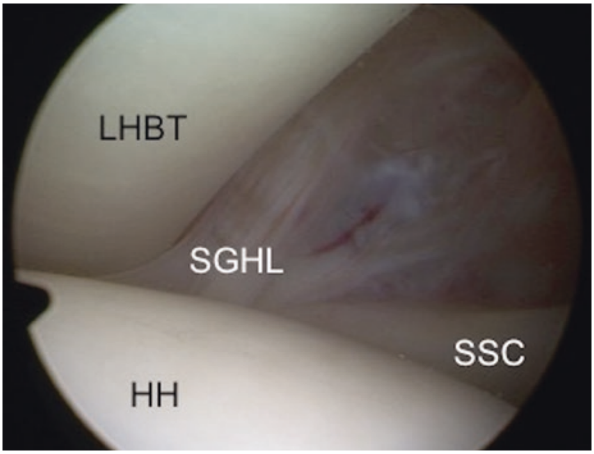

Fig. 1.10 Arthroscopic view from posterior of a left-sided shoulder. Following the inspection of the subscapularis tendon, the medial biceps reflexion pulley including the superior glenohumeral ligament is inspected. SSC, subscapularis tendon; HH, humeral head; SGHL, superior glenohumeral ligament; LHBT, long head of the biceps tendon

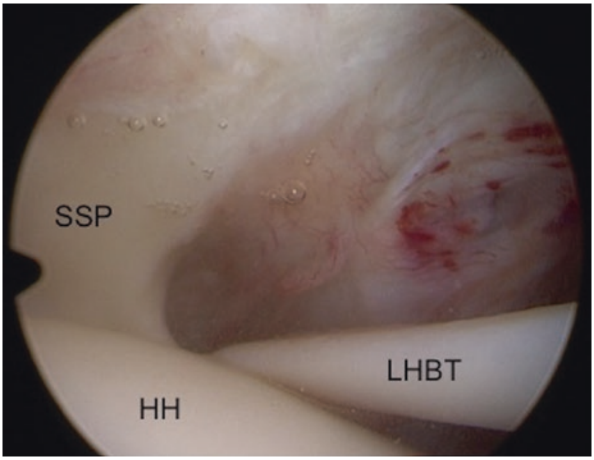

Fig. 1.11 Arthroscopic view from posterior of a left-sided shoulder. After inspection of the medial side of the biceps reflexion pulley, its lateral side is examined. SSP, supraspinatus tendon; HH, humeral head; LHBT, long head of the biceps tendon

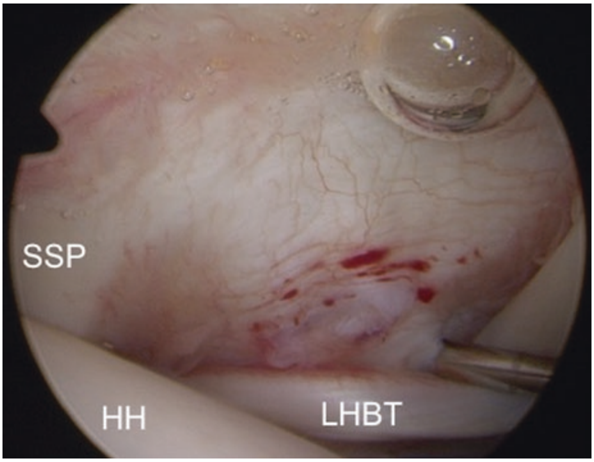

Fig. 1.12 Arthroscopic view from posterior of a left-sided shoulder. Also, a probe can retrieve the extraarticular portion of the long head of the biceps tendon by applying superior pressure, and then the tendon can be assessed for tears, tenosynovitis, and pulley pathology. SSP, supraspinatus tendon; HH, humeral head; LHBT, long head of the biceps tendon

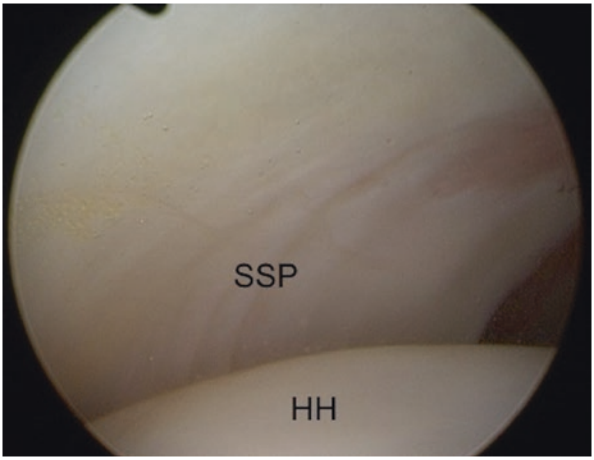

Fig. 1.13 Arthroscopic view from posterior of a left-sided shoulder. Next, the humeral insertion of the supraspinatus tendon is examined for a complete or partial articular rotator cuff tear. SSP, supraspinatus tendon; HH, humeral head

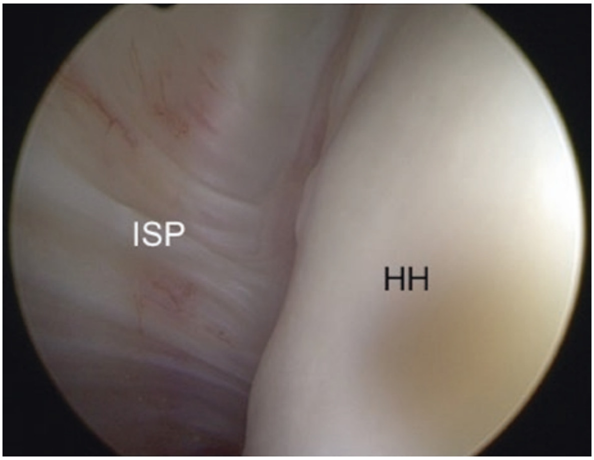

Fig. 1.14 Arthroscopic view from posterior of a left-sided shoulder. The humeral insertion of the infraspinatus tendon is also examined for a complete or partial articular rotator cuff tear. ISP, infraspinatus tendon; HH, humeral head

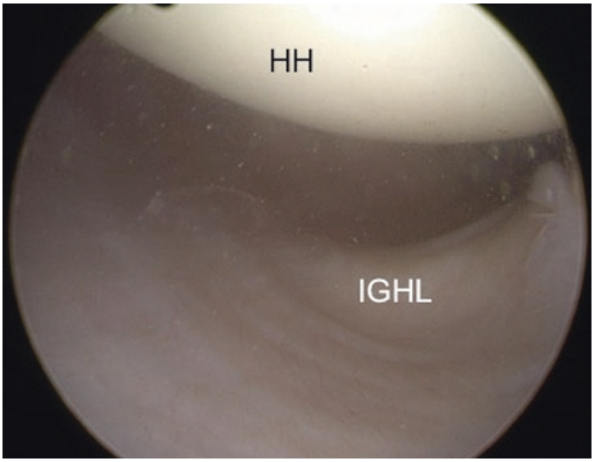

Fig. 1.15 Arthroscopic view from posterior of a left-sided shoulder. The inferior capsular recess is examined from posterior to anterior to identify loose bodies and/or any injuries to the humeral insertions of the glenohumeral ligaments. HH, humeral head; IGHL, inferior glenohumeral ligament

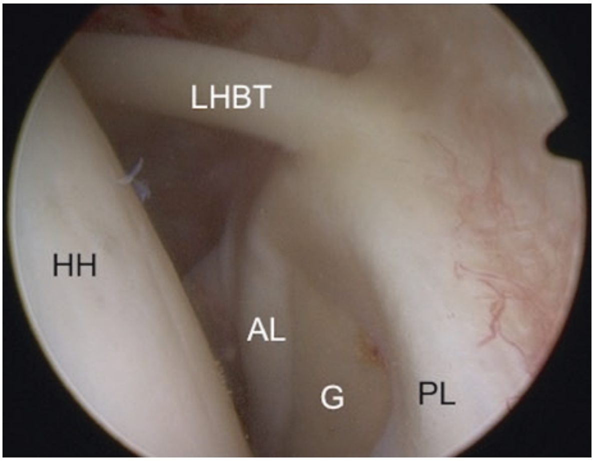

Fig. 1.16 Arthroscopic view from posterior of a left-sided shoulder. Finally, the assessment of the anterior and posterior labrum and the SLAP complex are performed. G, glenoid; HH, humeral head; LHBT, long head of the biceps tendon; AL, anterior labrum; PL, posterior labrum

lesion. The inferior capsular recess is examined from posterior to anterior to identify loose bodies and/or any injuries to the humeral insertions of the glenohumeral ligaments (Fig. 1.15). Finally, the assessment of the anterior and posterior labrum and the SLAP complex are performed (Fig. 1.16).

Upon completion of glenohumeral arthroscopy, the arthroscope is placed into the subacromial space. Inferior traction with forward flexion of the arm may increase the subacromial space and allow for better visualization. The bursa will often require resection using a combination of an arthroscopic shaver and a radio-frequency ablation device. Ensuring the cutting surface is pointed upward will aid in protecting the rotator cuff. In order to clear this space, removal of the undersurface of the anterolateral acromion with the radio-frequency device is recommended. The coracoacromial ligament constitutes the anterior border of the subacromial space with the deltoid fascia forming the lateral border. Subacromial bursectomy should be done without violating the deltoid fascia in order to prevent fluid extravasation and maintain muscle integrity. Next, the bursal side of the rotator cuff can be visualized. To help facilitate this visualization, the arthroscope should be switched to the lateral portal. Performing a dynamic examination by using combinations of adduction-abduction with internal-external rotation can help with visualization of the rotator cuff.

Discussion

This chapter outlined the steps needed to position a patient in the beach chair or lateral decubitus position for shoulder surgery. There are several advantages and disadvantages to both positions, which are summarized in Tables 1.1 and 1.2. Optimal patient positioning is essential to perform safe shoulder surgery. Team effort from the operating room staff helps facilitate patient positioning efficiently and also minimizes risk to the patient. After successful positioning, the establishment of standard and accessory portals ensures the arthroscopic surgeon can visualize anatomic and pathologic structures, as well as address these structures surgically. Portal placement and proper arthroscopic fluid management aid the surgeon in operating efficiently and effectively.

Table 1.1 Beach chair positioning for shoulder surgery: disadvantages and advantages

Disadvantages	Advantages
Expensive equipment for positioning, namely, the operating table	Anatomic positioning of the shoulder joint eases surgical intervention and orientation
Ulnar neuropraxia from inadequate padding at the elbow	Easily convert to open procedure
Operative table can prevent or restrict certain motions or visualization of certain aspects of the joint	Pneumatic arm holder allows positioning of the arm in numerous positions to facilitate specific visualization of shoulder pathology
Cervical neuropraxia (e.g., central cord syndrome) from inadequate padding and malposition of the head/neck	Lower incidence of peripheral neuropathies from excessive pressure
More potential risk for cerebral hypoperfusion	

Table 1.2 Lateral decubitus positioning for shoulder surgery: disadvantages and advantages

Disadvantages	Advantages
May need endotracheal anesthesia to secure airway	Cautery bubbles float out of view laterally
Orientation of the joint is nonanatomic	Better cerebral perfusion
Could require second sterile preparation and draping if conversion to open procedure is needed	Joint distraction eases visualization of labral pathology
Technically challenging to place anterior portal around the suspension device	Increased access to the glenohumeral joint with traction provided
Soft tissue injury and nerve injury risk if bony prominences inadequately padded	
Traction can theoretically lead to neuropraxia	

Part II

Rotator Cuff Tears

Subacromial Decompression

2

Patrick W. Kane, Jonas Pogorzelski, Erik M. Fritz, and Peter J. Millett

Introduction/Background

Nearly 20% of the adult population reports pain in the shoulder during a calendar year, and a large proportion of these patients are diagnosed with subacromial impingement syndrome. A thorough search for the underlying pathology is always indicated followed by an initial course of nonoperative treatment as first-line treatment and generally results in favorable outcomes. Surgery may be indicated for patients suffering from impingement due to a mechanical obstruction that fail physical therapy and injections. While subacromial decompression (SAD) with partial acromioplasty has long been recognized as an accepted surgical management option to help reduce mechanical impingement and optimize shoulder function, more recent literature has questioned its utility, particularly when done in isolation. Recent studies out of Finland and the United Kingdom have reported no significant difference in outcome scores between patients who have undergone subacromial decompression versus placebo surgery or a diagnostic arthroscopy underlining the critical need for a thorough preoperative examination. Subacromial decompression has historically helped reduce patient pain and symptoms from a variety of pain generators within the subacromial space including but not limited to subacromial bursitis, synovitis, adhesions, and subacromial impingement lesions. Additionally, large acromial spurs (e.g., ossifications of the coracoacromial

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ligament) have been shown to cause significant impingement and even bursal-sided tears of the underlying rotator cuff and thus need to be removed. Recent work by Gerber et al. and Katthagen et al. have also shown that a lateral acromioplasty can help to reduce large critical shoulder angles (CSA) which may be particularly helpful in cases of rotator cuff repair. Critical shoulder angles greater than 35° have been shown to be an independent risk factor for rotator cuff tears, repair failure, and abduction strength weakness. Recent studies, both biomechanical and clinical, have demonstrated that lateral acromioplasty can effectively improve CSA and shoulder mechanics without compromising the deltoid insertion and its function (Figs. 2.1 and 2.2).

Fig. 2.1 Preoperative true anteroposterior fluoroscopic image showing the critical shoulder angle

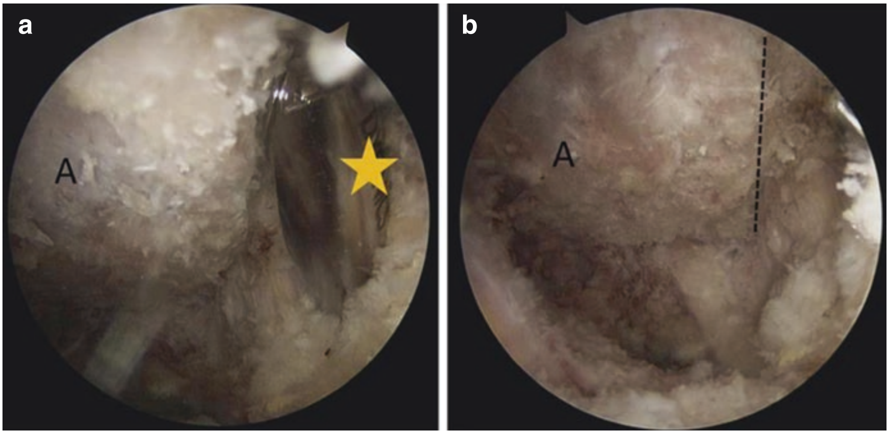

Fig. 2.2 Lateral acromion resection. Shoulder arthroscopy of the subacromial space through a posterior viewing portal (right shoulder): (**a**) lateral acromion resection with 5 mm burr (star) and (**b**) after lateral resection (in which the dotted line indicates the resection line)

In addition to improving shoulder mechanics, acromioplasty done in the setting of rotator cuff repair also offers several other benefits including improved visualization, removal of extrinsic compression, as well as the potential for an improved biologic environment for a healing response due to the release of marrow elements from bleeding bone.

Operative Principle

A subacromial decompression is generally performed arthroscopically using a posterior standard viewing and anterior standard working portal. A burr or shaver is inserted into the subacromial space and a bursectomy performed. Additionally, all mechanical obstacles such as spurs or scarred bursitis which might potentially damage the rotator cuff and thus cause pain are also removed.

Indication

SAD is indicated in patients with subacromial impingement and persistent shoulder pain despite a thorough course of nonoperative management including but not limited to physical therapy, anti-inflammatory medications, and/or subacromial injections. It is mainly used in combination with other reconstructive procedures such as rotator cuff repair surgeries. Subacromial decompression in isolation should be utilized with caution and only in cases of an outlet impingement with mechanical obstructions (Fig. 2.3) as results from recent European studies have questioned the benefits and results of this widely employed procedure. Acromial morphology is a known risk factor for an outlet impingement and typically classified using the classification scheme developed by Bigliani et al. with type 1 being normal and flat, type 2 as curved, and type 3 as hooked. In general, subacromial decompression with partial acromioplasty is considered in patients with type 2 and type 3 acromial morphology (Fig. 2.4).

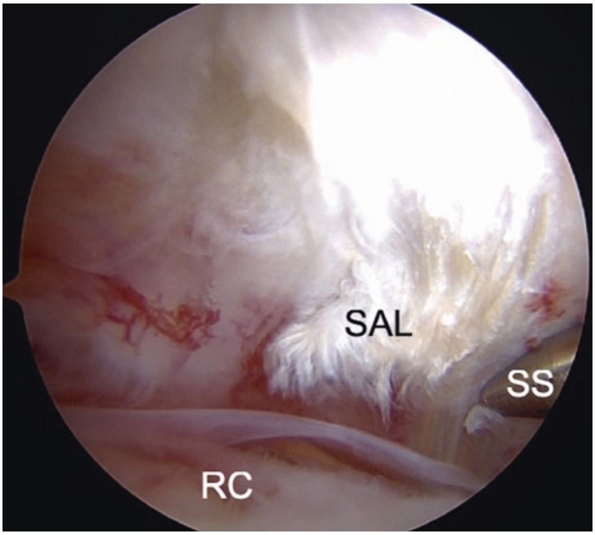

Fig. 2.3 Arthroscopic view of a right shoulder demonstrating a subacromial "impingment lesion" due to mechanical conflict such as a hook-shaped acromion with its pathognomonic fraying of the coracoacromial ligament insertion on the undersurface of the acromion. SAL, subacromial impingment lesion; SS, switching stick; RC, rotator cuff

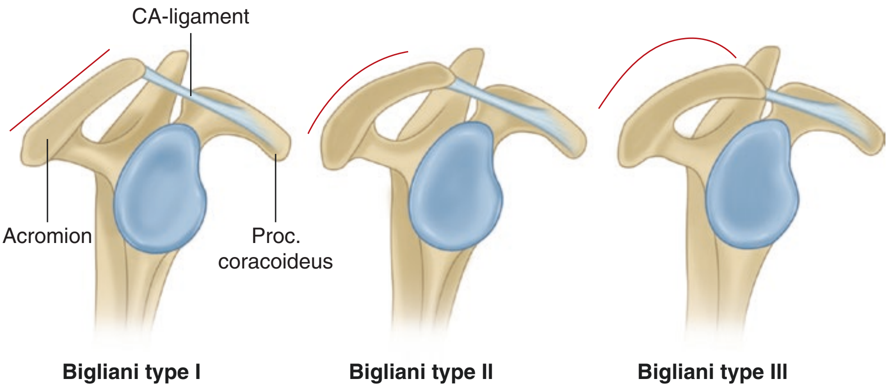

Fig. 2.4 Illustration demonstrating Bigliani classification for acromial morhphology. Type 1 flat, type 2 curved, type 3 hooked

Contraindications

In general, significant general medical comorbidities including cardiac disease, pulmonary disease, and active infection are contraindications to any surgery including an SAD. Care should be taken when performing a partial acromioplasty on patients with a history of previous SAD or a history of an os acromiale as this could lead to a higher risk of possible iatrogenic fracture of the acromion. Similarly patients with large, massive irreparable rotator cuff tears are not ideal candidates for subacromial decompression particularly when the coracoacromial (CA) ligament is released. In these patients, the CA arch should be preserved to help prevent or reduce the incidence of anterosuperior escape of the humerus.

Technique

Preoperative Preparation

After the induction of general anesthesia and placement of a regional interscalene block, the patient is placed in the beach chair position. The operative extremity is then situated in a pneumatic arm holder, and the operative shoulder and axilla are prepared and draped using standard sterile techniques.

Diagnostic Arthroscopy

A standard posterior viewing portal and an additional anterior working portal are created. A 5 mm × 7 cm cannula is inserted in the anterior working portal and a probe inserted. A standard diagnostic arthroscopy is performed, and any intra-articular pathology such as debridement or biceps tendon management is addressed at this time. Careful evaluation of the articular sided portion of the rotator cuff is also performed at this time.

Subacromial Decompression and Acromioplasty

Once all intra-articular work is completed, the arthroscope is then introduced into the subacromial space. If indicated, bursectomy, synovectomy, and subacromial spur removal can be performed. A standard anterolateral arthroscopic portal is made approximately two finger breadths lateral to the anterolateral border of the acromion. This portal should be made under direct visualization with the aid of a spinal needle to ensure the correct trajectory for accessing the undersurface of the acromion is achieved (Fig. 2.5).

A 4.5 mm arthroscopic shaver is used to complete a bursectomy in the subacromial space (Fig. 2.6).

A radiofrequency device is then introduced to help outline the border of the acromion and to peel back the coracoacromial ligament from the anterior edge of the acromion. Care should be taken during resection at the anterior edge of the acromion to avoid injury to the anterior acromial branch of the thoracoacromial artery as this could lead to bleeding and limit visualization during the remainder of the procedure. The acromial morphology as viewed arthroscopically should be compared to preoperative imaging, and any subacromial spurs or impingement lesions should be carefully resected. A 5.5 mm burr is used to perform a partial acromioplasty, using a standard cutting block technique. The width of the burr is a useful reference

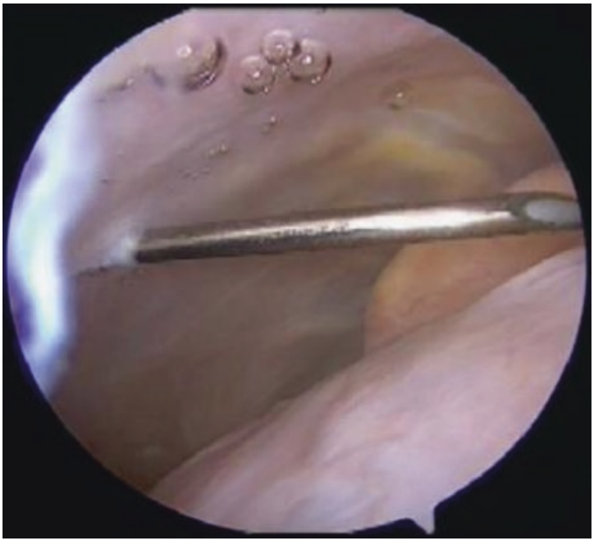

Fig. 2.5 Arthroscopic view of a left shoulder subacromial space as viewed from the posterior viewing portal. A spinal needle is being introduced through the proposed anterolateral portal and is in the correct trajectory to aid in easy access to the anterolateral acromion

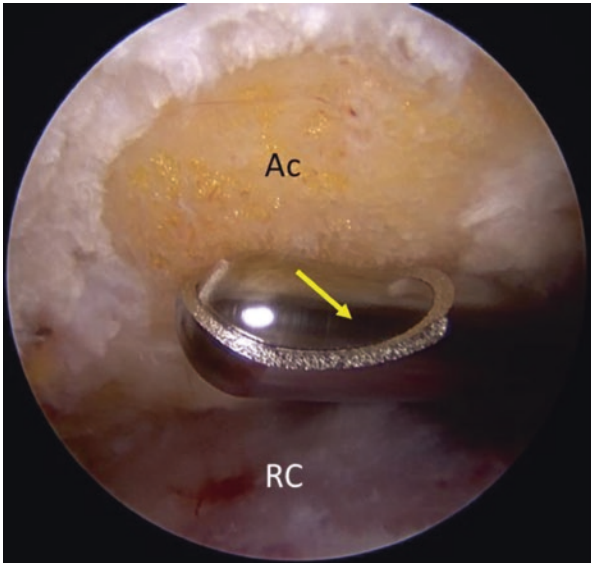

Fig. 2.6 Arthroscopic view of a right shoulder subacromial space through the posterior portal. Via the anterolateral portal, a 4.5 mm arthroscopic (arrow) shaver is used to complete the bursectomy. Ac, acromion; RC, rotator cuff

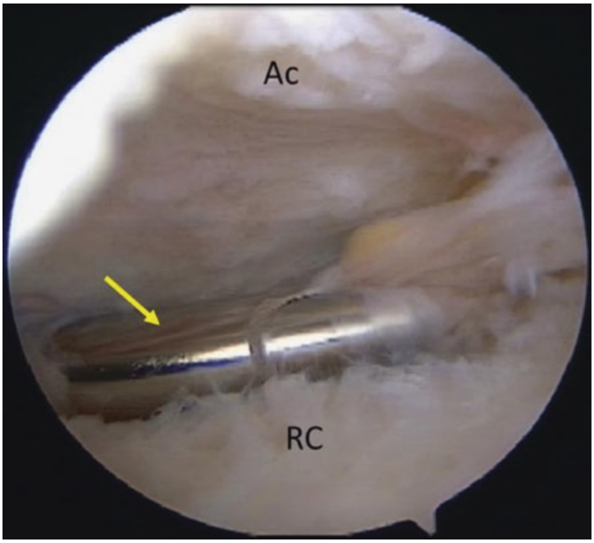

Fig. 2.7 Arthroscopic view of a left shoulder subacromial space as viewed from the anterolateral portal. Via the posterior portal, a 5.5 mm arthroscopic (arrow) burr is used to complete the partial acromioplasty using a standard cutting block technique for measured resection. Ac, acromion; RC, rotator cuff

tool to measure the amount of acromion that is resected and can be helpful in avoiding over resection which can lead to an acromial fracture (Fig. 2.7).

Care should be taken to preserve the acromioclavicular joint capsule if possible, unless a concomitant distal clavicle excision is going to be performed. Once the majority of the partial acromioplasty is completed, it is beneficial to move the camera from the posterior portal to an anterolateral portal to better gauge both the degree and regularity of resection of the undersurface of the acromion (Fig. 2.8).

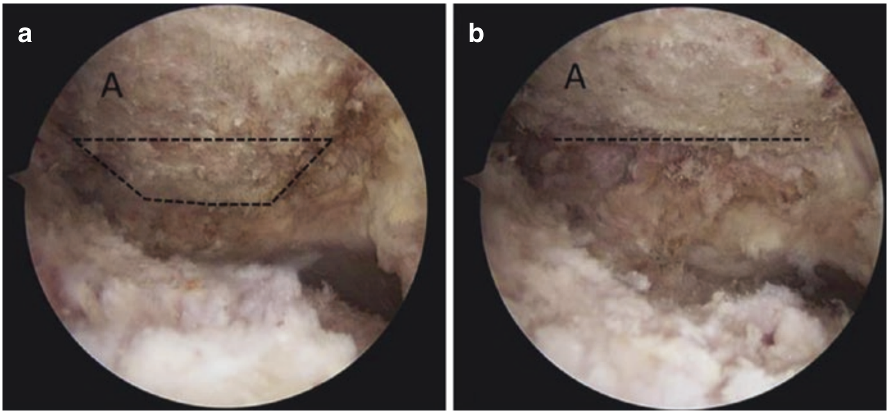

Fig. 2.8 Standard anterolateral acromioplasty. Shoulder arthroscopy of the subacromial space through a posterior viewing portal (right shoulder) (**a**) before standard anterolateral acromioplasty (in which the dotted line indicates the area to be resected) and (**b**) after standard anterolateral acromioplasty (in which the dotted line indicates the resection line after acromioplasty)

Postoperative Rehabilitation

The postoperative rehabilitation protocol following a subacromial decompression is largely dictated by any other concomitant procedures being performed at the time of partial acromioplasty. If a rotator cuff repair or biceps tenodesis is completed, the rehab protocols for those procedures should be followed. If, however, a subacromial decompression is performed in isolation, the postoperative rehabilitation protocol is initiated the following day, and both active and passive range of motion are unrestricted. A full recovery to all preoperative activities is typically achieved within 4–6 weeks.

Pearls and Pitfalls

Surgical step	Pitfalls	Pearls
Diagnostic arthroscopy	Missing concomitant lesions	Performing a thorough and standardized examination allows for identification of concomitant lesions
Subacromial decompression	Appropriate resection	Correct placement of the anterolateral portal will ensure the correct trajectory for accessing the acromion Switch the camera from the posterior portal to the AL portal to ensure thorough, adequate, and even resection
Subacromial decompression	Excessive bleeding	Judicious use of the shaver during bursectomy near the scapula spine as this area is highly vascularized; consider radiofrequency ablation of bleeding vessels in this area Care should also be taken near the anterior border of the acromion to avoid injury to the anterior acromial branch of the thoracoacromial artery
Postoperative rehabilitation	Postoperative stiffness	Early passive and active range of motion is initiated immediately, depending on any concomitant procedures performed

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Subscapularis Repair

3

Alexander R. Vap, David Constantinescu, Erik M. Fritz, and Peter J. Millett

Introduction/Background

The subscapularis (SSC) is an anteriorly located muscle of the rotator cuff and subsequently the most powerful internal rotator. The SSC function is crucial in maintaining the tension force balance with the three posteriorly located rotator cuff muscles. SSC tears are commonly found in conjunction with supraspinatus tears; however isolated SSC tears do occur and account for a small number of arthroscopically repaired rotator cuff tears (RCTs). Arthroscopic repair of SSC tears is a safe and successful procedure with improved outcomes in shoulder strength, range of motion, and pain as well as low complication rates.

Operative Principle

Anchoring of the subscapularis tendon to the humerus restores function of the muscle. Defining and classifying the extent of the tear are important as it can provide a framework for management.

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Two surgical options exist. An arthroscopic knotless single anchor is sufficient for tears of the upper part of the tendon. A double-row anchor fixation is required for larger tears.

Indication

Subscapularis repair is indicated in active patients of all ages with an irreparable partial or complete isolated tear of the subscapularis muscle. The purpose of repair is to preserve normal shoulder function, strength, and stability. Prolonged non-operative treatment may lead to progression of tear size and fatty muscle infiltration over time with increasing difficulty for a successful repair.

Contraindications

Contraindications to surgery are significant medical comorbidities including cardiac disease, pulmonary disease, and active infection. Additional potential contraindications are massive glenohumeral osteoarthritis, fatty infiltration of the subscapularis muscle, and neuronal damage in which case reverse shoulder arthroplasty is the preferred treatment.

Technique

Anesthesia and Patient Positioning

After induction of general anesthesia and placement of an interscalene block, the patient is placed in the beach chair position with placement of the operative extremity in a pneumatic arm holder. The beach chair position facilitates manipulation of the shoulder for optimal visualization as well as the possibility of easy conversion to an open procedure if required. The acromion, clavicle, and coracoid process are marked for use as bony landmarks on the skin.

Diagnostic Arthroscopy and Portals

Diagnostic arthroscopy is performed with a standard 30° arthroscope through a standard posterior viewing portal approximately 2 cm inferior and 2 cm medial to the posterolateral acromion. Better visualization of the subscapularis and lesser tuberosity may be achieved through abduction, internal rotation (IR), or external rotation (ER) of the operative extremity. Following diagnostic arthroscopy, an anterior working portal is created under direct visualization with spinal needle localization through the rotator interval. This allows access to the lesser tuberosity at about a 45° angle and will be used for anchor placement and suture management. Using a similar approach, the anterolateral portal is established next anterior and slightly medial to the anterolateral acromion. This results in the portal approaching the tendon at a nearly parallel angle, which optimizes preparation of the lesser tuberosity, mobilization of the SSC, and easy suture passage.

Biceps Tendon

Diagnostic arthroscopy should also inspect the long head of the biceps tendon, as disruptions of the biceps reflection pulley (BRP) are commonly associated with subscapularis tears. If a biceps pulley lesion or biceps tendon tear is discovered, biceps tenotomy should be performed with subsequent subpectoral tenodesis. Failure to treat BRP lesion can cause patients to have persistent pain and even failure of the SSC repair postoperatively.

Coracohumeral Interval

Intraoperative evaluation of the coracohumeral interval is imperative due to the association of subcoracoid impingement with SSC tears. Intraoperative visualization of subcoracoid impingement is achieved with operative extremity manipulation through its ROM of abduction, flexion, and internal rotation. Moreover, when preoperative axial MRI demonstrates narrowing of the coracohumeral interval to <10 mm in males and <8 mm in females, coracoplasty is indicated. In addition to treating coracoid impingement, coracoplasty also increases the working space, making the subsequent SSC repair technically easier.

Coracoplasty and subcoracoid decompression begin by using an arthroscopic shaver and radio-frequency device through the anterior working portal to create a window into the rotator interval. The window is created just above the superior border of the subscapularis to expose the coracoid. Using the radio-frequency device, soft tissue is removed from the tip and posterior aspect of the lateral coracoid. Next, a 4 mm burr is used through the anterior portal to remove approximately 3–5 mm of the latero-inferior side of the coracoid.

Subscapularis Tendon

Using an arthroscopic grasper via the anterolateral portal, tendon mobility should be assessed. The repair may be performed immediately if the tendon mobilizes to the lesser tuberosity easily, as is seen with acute tears. However, a three-sided release must be performed if the tendon does not mobilize. A suture or grasper may be used at the superior border of the SSC tendon to provide traction during the release.

The three-sided release consists of anterior, superior, and posterior aspects of the SSC tendon in sequential order. The anterior aspect is released by dissecting the soft tissue between the anterior SSC and the coracoid process. The superior aspect of the tendon is released by lysing the adhesions between the lateral arch of the coracoid process and the superior aspect of the subscapularis. Precaution should be taken to not dissect medial to the base of the coracoid so as to prevent iatrogenic injury of the musculocutaneous nerve, axillary nerve, and axillary artery. Finally, the posterior aspect is released by dissecting the subscapularis from the glenoid neck. As part of this step, the capsulolabral interval commonly needs to be divided to accomplish this final release. Often times, complete release of the coracohumeral ligament (CHL) and medial glenohumeral ligament (MGHL) may also be necessary. Mobilization is confirmed when the SSC tendon adequately reduces to the lesser tuberosity using the arthroscopic grasper.

For repair of tears of the upper one third of the SSC, the arthroscope may remain in the posterior viewing portal. However, large tears may be obscured by the inferior glenohumeral ligament (IGHL), in which case the anterolateral portal or an open approach should be used for appropriate visualization.

Arthroscopic Trans-articular Approach

Debridement of the torn subscapularis edges is achieved using a 5 mm shaver through the anterior working portal until there is a stable margin of healthy tissue with healing capacity. The SSC footprint on the lesser tuberosity is prepared using a using a 4 mm burr, which creates a bleeding bony surface to enhance and facilitate healing.

The most common subscapularis tendon tear is that of the upper one third to one half (Fig. 3.1). Tears of this magnitude can be repaired using a single anchor.

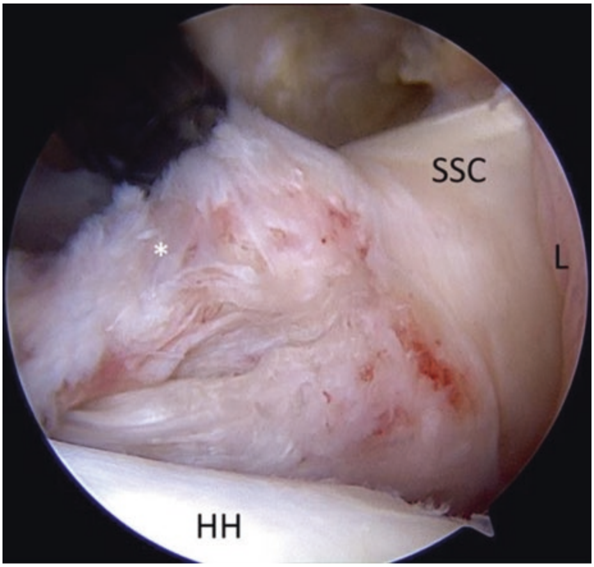


Fig. 3.1 Arthroscopic view of a left shoulder through the standard posterior viewing portal demonstrating a delaminated full-thickness tear (*) of the upper one half of the subscapularis tendon (SSC). HH = humeral head; L = labrum

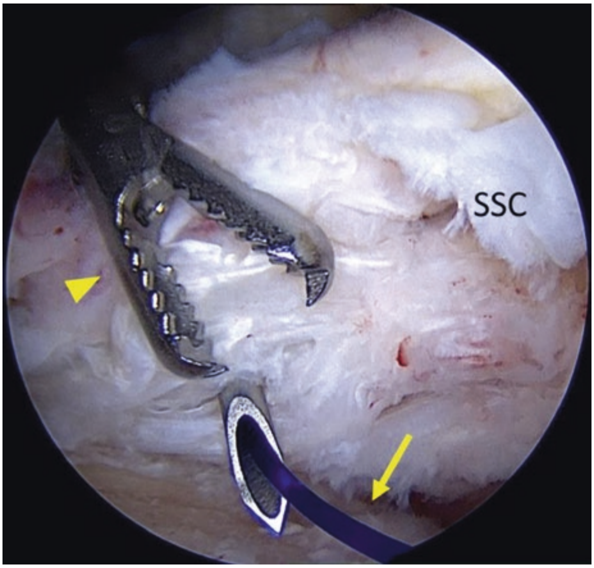


Fig. 3.2 Arthroscopic view of a left shoulder through the standard posterior viewing portal demonstrating a subscapularis tendon tear. An 18 gauge spinal needle is inserted inferior to the anterior working portal and through the subscapularis tendon (SSC), a #1 PDS suture (arrow) is passed through the spinal needle, and an arthroscopic grasper (arrowhead) pulls the Ethibond suture through the anterior working portal

Through direct visualization using the posterior viewing portal, an 18 gauge spinal needle is inserted percutaneously, inferior to the anterior working portal, and through the subscapularis tendon (Fig. 3.2). A #1 PDS suture is advanced through the spinal needle and pulled with an arthroscopic grasper out the anterior working portal.

A limb of suture tape is then secured to the limb of #1 PDS exiting the anterior working portal. Gently pulling the percutaneous limb shuttles the suture tape through the anterior portal, through the SSC, and out the skin percutaneously (Fig. 3.3). A grasper is then used through the anterior working portal to retrieve the percutaneous limb of the suture tape. As a result, both limbs of the tape exit the anterior working portal, creating a sling through the SSC (Fig. 3.4).

An arthroscopic shaver is used to prepare the SSC footprint by creating a bleeding bony surface on the lesser tuberosity to enhance healing, followed by the use of a radio-frequency device which is used to mark the location for anchor placement. A bone socket for the suture anchor is created using a punch (Fig. 3.4). Suture tape limbs are then threaded through the unloaded eyelet of a 4.75 mm knotless suture anchor, and the anchor is passed into the joint (Fig. 3.5). The suture limbs are pulled to generate the appropriate amount of tension on the SSC, at which point the anchor is finally placed (Fig. 3.6). The free ends of the suture tape are cut, resulting in completion of a knotless single-anchor repair construct. Single-anchor repairs of partial- or full-thickness tear of Lafosse Type I and II tears have been retrospectively analyzed by Katthagen et al., to show high postoperative clinical outcome scores as well as high patient satisfaction, significantly improved clinical function, and significantly decreased pain postoperatively.

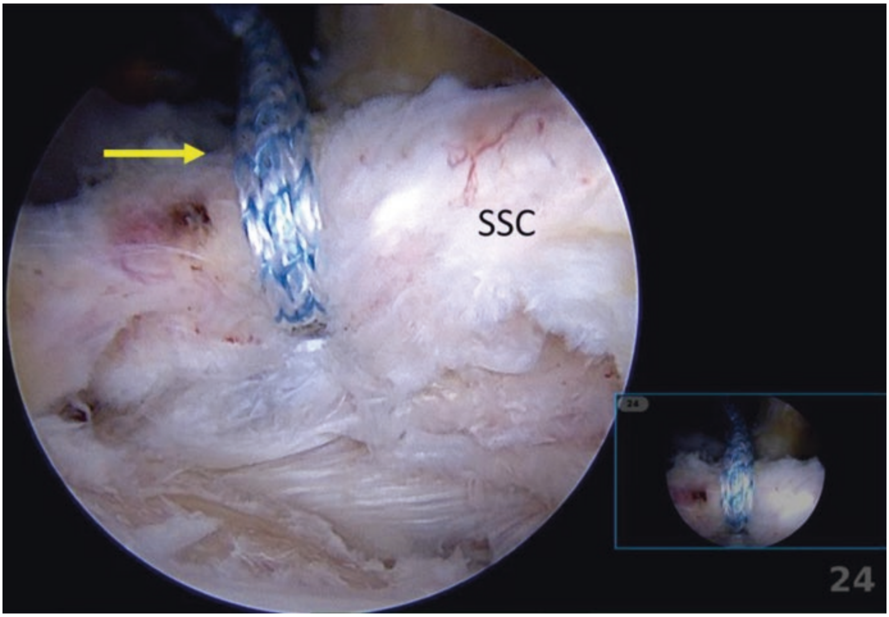
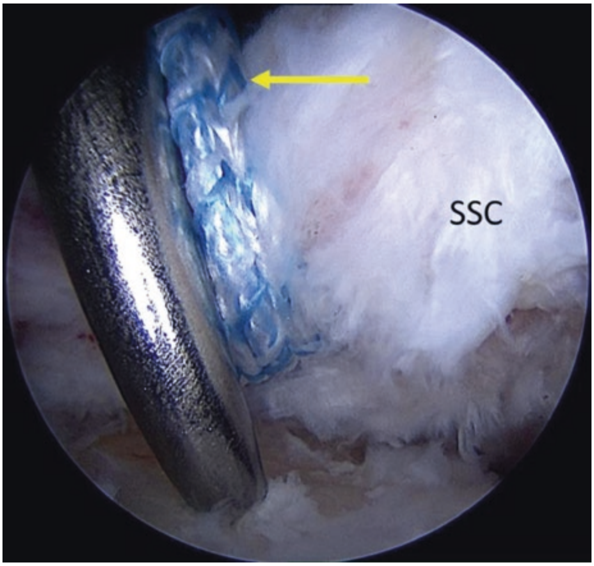


Fig. 3.3 Arthroscopic view of a left shoulder through the standard posterior viewing portal demonstrating a subscapularis tendon tear. The suture tape (arrow) has been shuttled via the Ethibond suture through the anterior working portal, through the subscapularis tendon (SSC), and out the skin percutaneously (not seen here)

Fig. 3.4 Arthroscopic view of a left shoulder through the standard posterior viewing portal demonstrating the subscapularis tendon (SSC). The suture tape (arrow) is passed through the tendon, and both limbs are exiting the anterior working portal. An arthroscopic punch (arrowhead) is used to prepare the bone socket for subsequent suture anchor placement



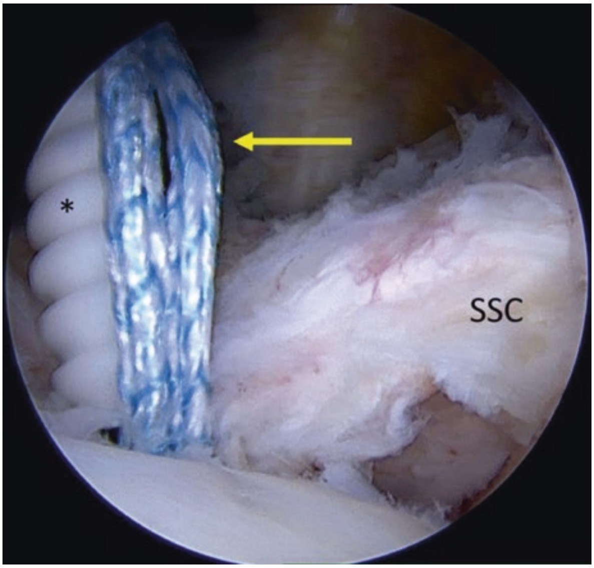


Fig. 3.5 Arthroscopic view of a left shoulder through the standard posterior viewing portal demonstrating the subscapularis tendon (SSC). The suture tape (arrow) has been loaded through the eyelet of the 4.75 mm knotless suture anchor (*). Appropriate tension is applied to the SSC tendon via the suture tapes, and the anchor is loaded into the previously placed bone socket

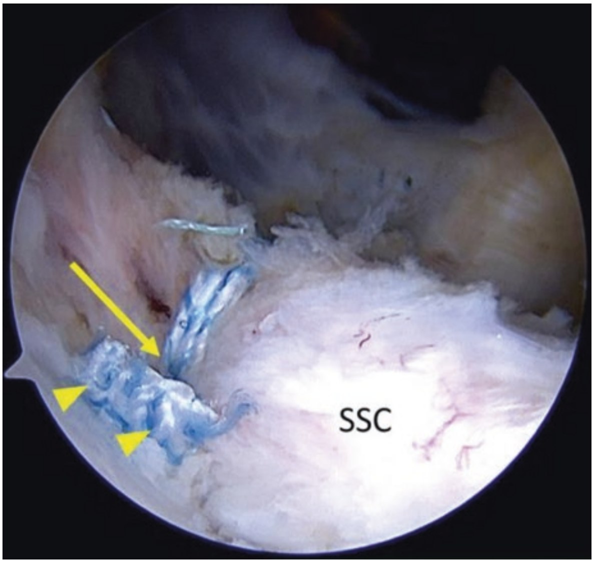


Fig. 3.6 Arthroscopic view of a left shoulder through the standard posterior viewing portal demonstrating the completed knotless single-anchor repair of the subscapularis tendon (SSC). The suture anchor (arrow) has been placed, and the free ends of the suture tape have been cut (arrow heads)

Arthroscopic Extra-articular Approach

The anterolateral portal should be used for visualization of the SSC tendon with high-grade full-thickness tears (Fox and Romeo Type III and IV) as the view may be obscured by the IGHL. This allows for a better view down the SSC and may facilitate the mobilization of a retracted tear. In most cases, a knotless double-row construct should be utilized for repair of larger tears of Fox and Romeo Type III and IV. A knotless double-row construct allows for even distribution of the compressive forces throughout the SSC tendon footprint. The SSC tendon footprint resembles a trapezoidal shape, unlike the square tendon footprint shape of the supraspinatus. Therefore, placing the superior-medial anchor more medially than the inferior-medial anchor optimizes biomechanical load distribution. This results in a skewed double-row repair that fully covers the footprint. A superior-inferior bone bridge of about 10 mm in an inferior-lateral direction between each medial anchor is maintained.

For the medial-row, double-loaded anchors are placed on the lesser tuberosity about 1–2 mm lateral to the articular margin through the anterior portal with subsequent sutures passed through the tensioned tendon using a tissue-penetrating device. One suture from each medial-row anchor is preloaded into the eyelet of the lateral row anchors, which are then placed approximately 15 mm lateral to their corresponding medial anchor. Adequate tension is obtained by pulling the suture tapes, which allows for the tendon to be secured and completely cover the lesser tuberosity footprint. If required, side-to-side sutures may also be used to secure the SSC tendon to the leading edge of the supraspinatus tendon. Careful attention must be paid to leave the rotator interval open so as not to restrict postoperative external rotation. The SSC tendon repair is then complete.

Following completion, the arm mobility and anterior instability are tested through range of motion. All arthroscopic instruments are then removed, and the portals are closed in standard fashion.

Open Approach for Massive and Contracted Subscapularis Tears

In more challenging cases involving a full-thickness SSC tear, the surgeon may consider an open approach, as an arthroscopic view may be limited. Following a diagnostic arthroscopy, an approximately 10 cm standard deltopectoral incision is made. After carefully dissecting the subcutaneous tissue down to the fascia in the deltopectoral groove, the cephalic vein is exposed and retracted laterally. If necessary, the vein may be ligated. Dissecting laterally to the conjoint tendon and retracting it medially protects the brachial plexus and brachial vessels. This allows for the anterior glenohumeral joint to be exposed and thus reveals the subscapularis and anterior capsular deficiency (Fig. 3.7).

For reparable tears, a knotless double-row construct is used, in an identical fashion as described above**.** If necessary, more anchors can be incorporated into the knotless double-row construct (Fig. 3.8). Open repair for isolated tears of the caudal subscapular tendon has been shown to improve outcomes with diminished pain and regained shoulder function.

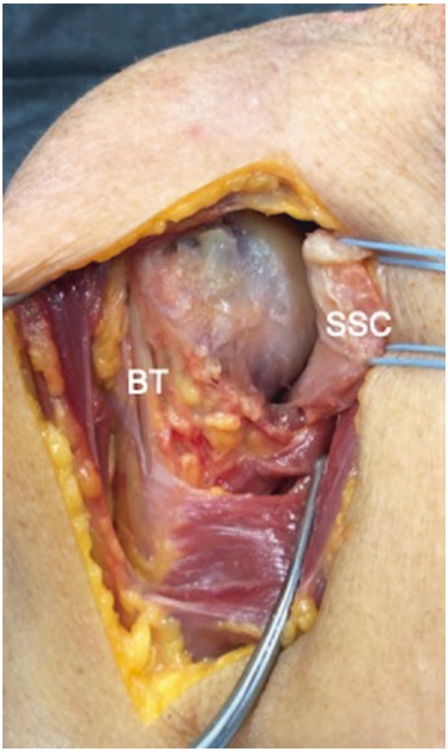


Fig. 3.7 View of a right shoulder deltopectoral approach for open subscapularis repair. SSC, subscapularis; BT, long head of the biceps tendon

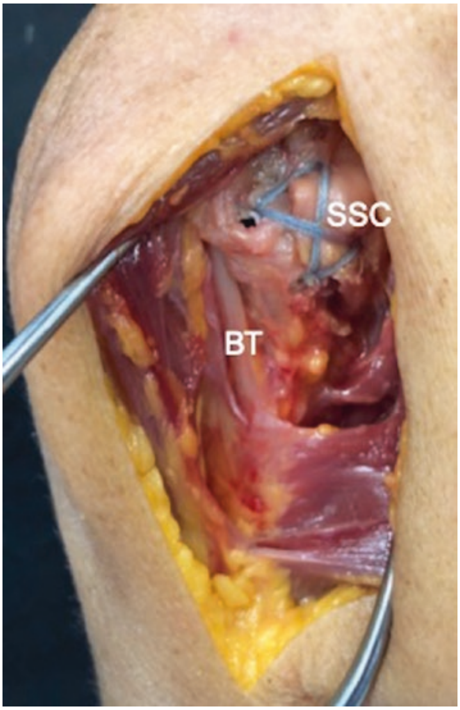


Fig. 3.8 View of a right shoulder following open subscapularis repair. SSC, subscapularis; BT, long head of the biceps tendon

Pearls and Pitfalls

Pearls and pitfalls of arthroscopic subscapularis repair.

Surgical steps	Pitfalls	Pearls
Anterior working portal placement	Poor portal placement can make tendon repair technically difficult	Create portal lateral to coracoid and inferior to CA ligament permitting 45° access to the lesser tuberosity and helping anchor placement
Biceps tendon	A dislocated biceps tendon may injure the subscapularis tendon leading to re-rupture	Perform biceps tenodesis to decrease risk of re-rupture
Subcoracoid decompression and coracoplasty	A too far medial decompression may put neurovascular structures at risk. Too much resection of the coracoid process may lead to an iatrogenic fracture	Remain on the lateral side of the coracoid while dissecting and do not to resect more than 5 mm of the latero-inferior side of the coracoid
Subscapularis tendon repair	Insufficient view	For SSC tears of the upper third, the posterior portal can be permanently used as camera portal. For bigger tears, the camera should be switched to an anterior portal
Subscapularis tendon repair	Insufficient repair	For SSC tears Fox/Romeo Type I and II, a single-anchor repair is most commonly sufficient. For SSC tears Fox/Romeo Type III and IV, a knotless double-row construct should be used

Postoperative Management

The rehabilitation program has four stages but is individualized to each patient based upon tear size, tissue quality, and security of the repair. In the majority of cases, stage 1 consists of arm immobilization in a sling for 6 weeks with external rotation restriction at 30°. The arm may come out of the sling for passive range of motion (PROM) beginning with pendulum exercises and advancing to low-load passive mid-ROM exercises. In patients with poor tissue quality or a less secure repair, ER is restricted to 0° throughout stage 1. Stage 2 occurs between weeks 7 and 12 and consists of the patient being weaned off of the sling and progressing to active-assisted and active range of motion through the full range of the shoulder. Initiation of end-range stretching and joint mobilization techniques may be used at this stage. In stage 3, between 13 and 16 weeks, the patient begins strengthening exercises if sufficient glenohumeral and scapulothoracic kinematics have been achieved in the previous stage. Should patients experience persistent ROM limitations, prolonged passive- and active-assisted ROM exercises, stretching, and manual therapy are initiated. Stage 4 takes place approximately from 17 to 22 weeks when the patient has achieved sufficient rotator cuff strength. The focus of the final stage is strengthening of the larger muscles of the shoulder, including the pectoralis major, latissimus dorsi, and deltoid muscles, and transitioning to full return to activities.

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Postero-superior Rotator Cuff Tears

4

Patrick W. Kane, Jonas Pogorzelski, Erik M. Fritz, and Peter J. Millett

Introduction/Background

The supraspinatus and infraspinatus tendons, commonly referred to as the postero-superior rotator cuff, are also the most frequently injured rotator cuff tendons and when torn can result in a significant amount of shoulder pain and disability. Traditionally, rotator cuff tear patterns have been described using one- or two-dimensional classification systems (small, medium, large, or massive). Although these classification systems were an improvement on previous schemes, important variables related to treatment and prognosis were not being captured. More recently developed three-dimensional classification schemes have been an essential step in improving treatment outcomes, as specific patterns are associated with favorable results when the correct repair technique is chosen. Advancements in both arthroscopy and advanced imaging have allowed for improved identification of these tear patterns. Although several classifications exist, the most widely adopted system in current use categorizes tears as either crescent, U-shaped, L- or reversed-L-shaped or massive, contracted, immobile tears. The specific tear pattern is important as each pattern has a recommended treatment method based on biomechanical considerations.

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Operative Principle

Indication

Rotator cuff repair is indicated in active patients of any age with a rotator cuff tear and persistent shoulder pain and weakness despite a thorough course of nonoperative management including but not limited to physical therapy, anti-inflammatory medications, and/or subacromial injections. Correlation of patient pain and symptoms with physical exam and imaging is important as a large percentage of the general population has evidence of asymptomatic rotator cuff tears on routine imaging, particularly with advancing age.

Contraindications

In general, significant general medical co-morbidities including cardiac disease, pulmonary disease, and active infection are contraindications to any surgery including rotator cuff repair. Patients with evidence of complex, retracted, immobile tear patterns are likely not ideal candidates for rotator cuff repair as a significant amount of tension (Patte grade 3) on the repaired tendons will likely lead to failure. Similarly, patients with significant fatty infiltration/atrophy of the rotator cuff (Goutallier stage 3–4) are also not ideal candidates for repair. Chronologic age is not a strict contraindication to rotator cuff repair, as several studies have shown positive outcomes of rotator cuff repair, even in patients over the age of 70.

Technique

Preoperative Preparation

After the induction of general anesthesia and placement of a regional interscalene block, the patient is placed in the beach chair position. The operative extremity is then situated in a pneumatic arm holder, and the operative shoulder and axilla are prepared and draped using standard sterile techniques.

Diagnostic Arthroscopy

A standard posterior viewing portal and an additional anterior working portal are created. A 5-mm × 7-cm cannula is inserted in the anterior working portal and a probe inserted. A standard diagnostic arthroscopy is performed and any intra-articular pathology such as debridement or biceps tendon management is addressed at this time. Careful evaluation of the articular-sided portion of the rotator cuff is also performed at this time.

Subacromial Decompression and Acromioplasty

Once all intra-articular work is completed, the arthroscope is then introduced into the subacromial space. If indicated, bursectomy, synovectomy, and subacromial spur removal can be performed. A standard anterolateral arthroscopic portal is made approximately two finger breadths lateral to the anterolateral border of the acromion. A 4.5 mm arthroscopic shaver is used to complete a bursectomy in the subacromial space. A radiofrequency device is then introduced to help outline the border of the acromion and to peel back the coracoacromial ligament from the anterior edge of the acromion. The acromial morphology as viewed arthroscopically should be compared to preoperative imaging, and any subacromial spurs or impingement lesions should be resected. A 5.5 mm burr is used to perform a partial acromioplasty, using a standard cutting block technique. Care should be taken to preserve the acromioclavicular joint capsule if possible, unless a concomitant distal clavicle excision is going to be performed. Once the majority of the partial acromioplasty is completed, it is beneficial to move the camera from the posterior portal to the anterolateral portal to better gauge both the degree and regularity of resection of the undersurface of the acromion.

Rotator Cuff Repair

In general, a thorough subacromial decompression should be completed in order to allow for adequate visualization of the underlying rotator cuff. Once completed, the arthroscope should be switched to the lateral portal as most tear patterns are best visualized through this bird's-eye or 50 yard line view. Next, medial-lateral and antero-posterior mobility must be assessed to determine the tear pattern. This can be accomplished using a grasper, with or without a reduction stitch. This method allows for a complete evaluation of tendon mobility, tissue quality, and tendon suture-holding properties, which is an essential step before choosing an appropriate repair technique.

Crescent-Shaped Tears

Crescent-shaped tears are the most common tear pattern configuration and account for approximately 40% of all tears to the postero-superior rotator cuff. Crescent-shaped tears represent a direct avulsion off of the greater tuberosity and have excellent inherent tissue mobility. As a result, they are very amenable to a direct and tension-free repair back down to bone and are usually associated with good to excellent outcomes (Figs. 4.1, 4.2, and 4.3).

U- and V-Shaped Tears

U- and V-shaped tears comprise approximately 15% of all complete tears and extend much more medially toward the glenoid than crescent-shaped tears. Because of this deeper extension, U- and V-shaped tears are often much more immobile in the medial and lateral plane. This immobility has important implications for repair, as tension and therefore failure rates are much higher when attempting to directly repair this deep, medial extension or apex back to the greater tuberosity. Instead, a technique commonly referred to as margin convergence has been shown biomechanically to reduce tension at the repair site and clinically has led to good to excellent outcomes in the treatment of this particular tear configuration. In this technique, a side-to-side repair of the deep limb or apex is performed first (essentially converting the U or V to a small crescent) and then followed by a direct repair to the tuberosity (Fig. 4.4).

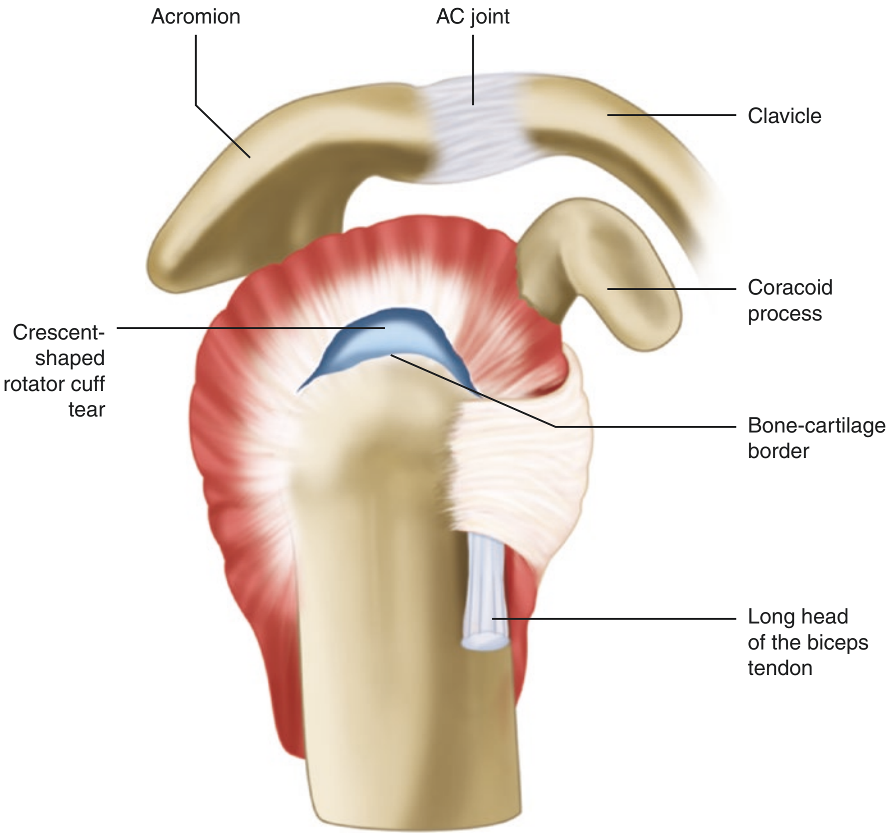

Fig. 4.1 Illustration depicting a crescent-shaped rotator cuff tear

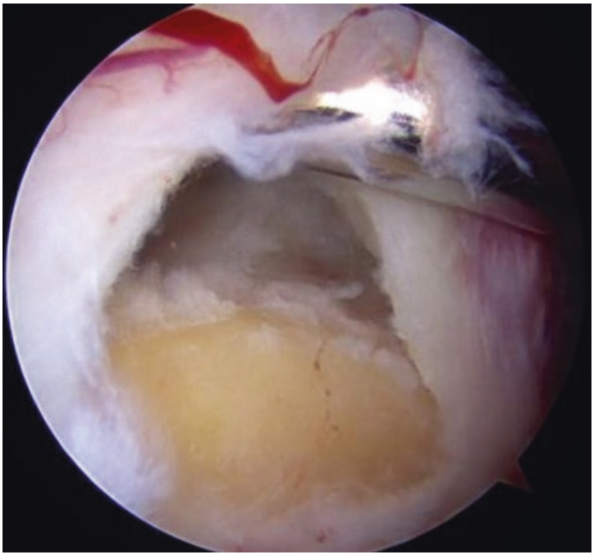

Fig. 4.2 Arthroscopic image of a right shoulder depicting with an arthroscopic grasper grasping the rotator cuff tissue involved in a crescent-shaped rotator cuff tear

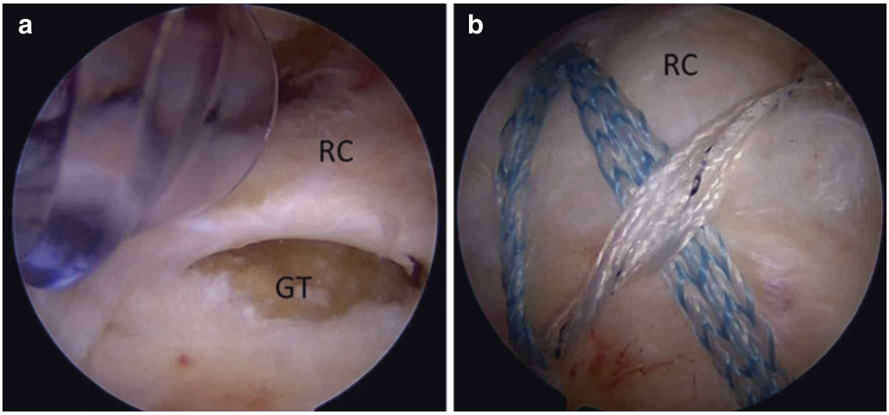

Fig. 4.3 Arthroscopic view of a left shoulder through the lateral portal demonstrating a crescent-shaped full-thickness rotator cuff tear. (**a**) The tear is appreciated here. (**b**) The final double-row knotless construct is viewed here. GT, greater tuberosity; RC, rotator cuff

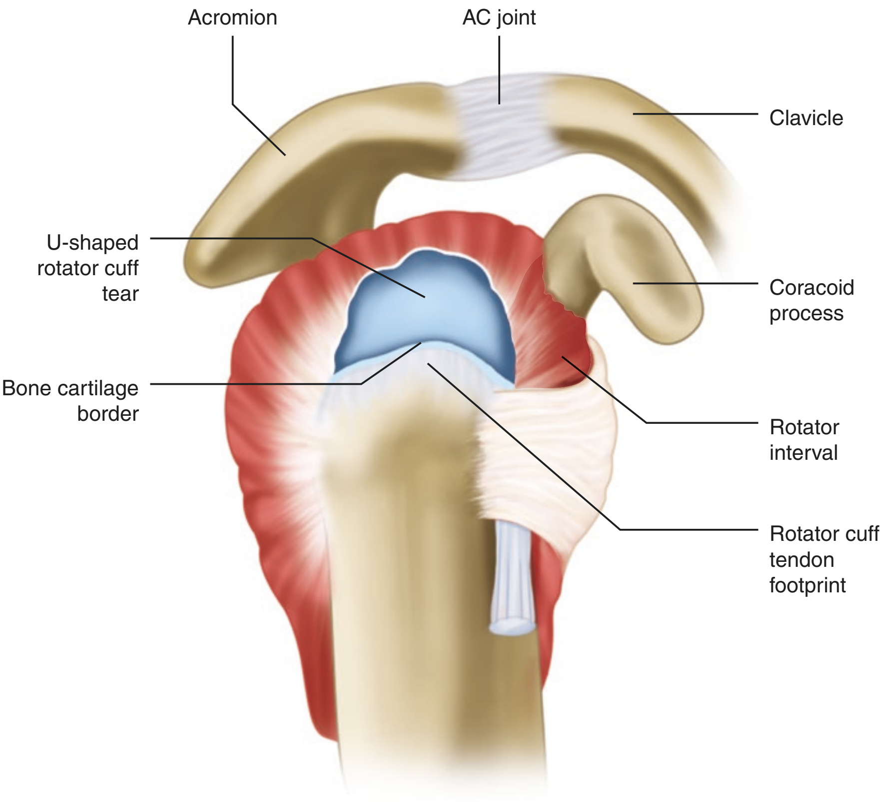

Fig. 4.4 Illustration depicting a U-shaped rotator cuff tear

L- and Reverse L-Shaped Tears

L- and reverse L-shaped tears account for almost 30% of rotator cuff tears and are defined by their transverse as well as longitudinal tear components. L-shaped tears traditionally propagate in the interval between the supraspinatus and the rotator interval while Reverse L shaped tears prpagate between the supraspinatus and the infraspinatus. In these particular tears, one limb of the "L" is more mobile than the other, and repair typically begins by anchoring the free edge with either a reduction stitch or a single suture anchor first followed by a side-to-side repair of the longitudinal split. Similar to the margin convergence technique used for V- or U-shaped tears, once the tension has been reduced with the side-to-side repair, the free edge or "crescent" is then repaired directly to the bone. Chronic L-shaped tears frequently develop a larger, U-shaped component, and careful examination of the relative mobility of each free margin should be performed to ensure the "corner" is re-approximated at the correct location (Fig. 4.5).

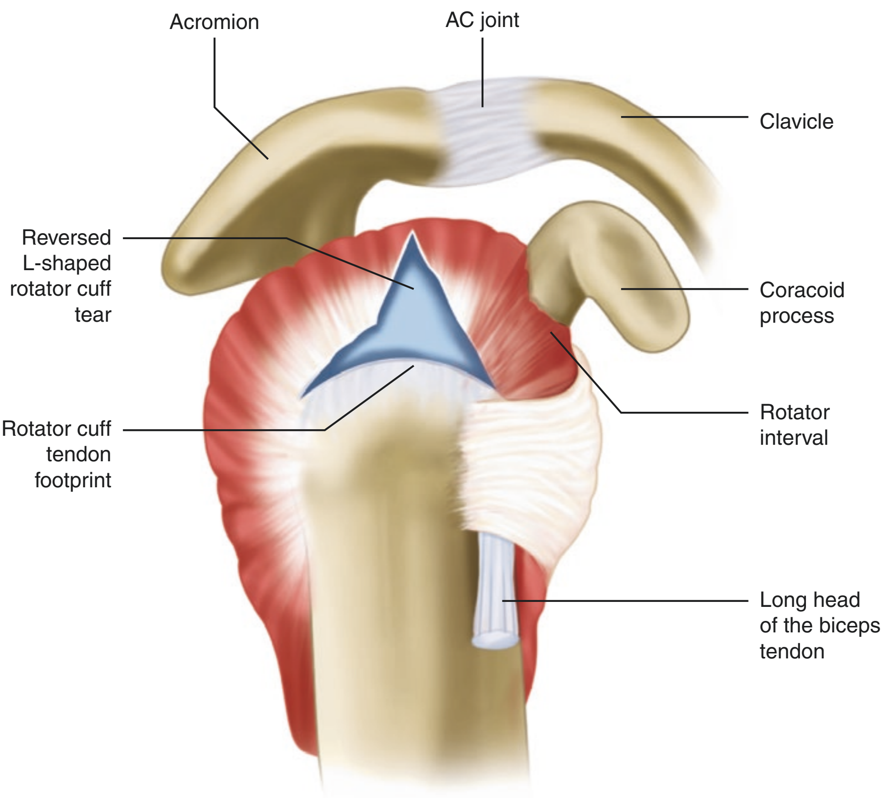

Fig. 4.5 Illustration depicting a reverse L-shaped tear

Massive, Contracted, Immobile Tears

Massive and contracted tears are fortunately much less common than the tears mentioned previously, but they are substantially less mobile and traditionally have been referred to as "irreparable" tears. Although clinical outcomes of these repairs are still guarded, advancements in arthroscopic techniques have improved overall results. Various interval slide techniques have been advocated to help improve rotator cuff mobility, particularly of the supraspinatus. The more widely used anterior interval slide technique is performed by incising the coracohumeral ligament near the base of the coracoid at the inferior margin of the supraspinatus tendon and the superior margin of the rotator interval. If the supraspinatus tendon is still relatively immobile following an anterior interval slide, a posterior slide can be completed as well by developing the interval between the supraspinatus and infraspinatus. The posterior interval slide has not been as widely adopted because of its disruption of intact tendons and also its close proximity to the suprascapular nerve at the base of the scapular spine, but it can be employed as part of a "double slide" technique if sufficient mobility of the rotator cuff cannot be achieved through other methods.

Repair Techniques

Although a wide variety of rotator cuff repair techniques are available, the main repair constructs in current use today are single- versus double-row fixation. Single-row repair had been a mainstay of treatment for many years until double-row repair, a technique in which an additional medial row of anchors is placed just lateral to the articular margin, was introduced in an attempt to enhance healing rates by improving the anatomic restoration of the rotator cuff footprint on the greater tuberosity. Many biomechanical studies have shown a superiority of the double-row technique, citing improved anatomical restoration, footprint compression, tendon-to-bone contact, and increased mechanical and cyclical strength. Although single-row repair constructs have also improved over time with advancements such as double-loaded or triple-loaded suture anchors, subjective, objective, and structural outcomes favor double-row repair in most cases, particularly with newer, linked double-row constructs. These linked constructs preserve the suture limbs of the medial row and "bridge" them over the footprint insertion to a distal and lateral row of suture anchors. This configuration has several distinct advantages including avoidance of both sutures and anchors at the tendon-bone interface where healing occurs, improved compression of the anatomic footprint of the rotator cuff, as well as development of a "Chinese finger trap" construct in which the grasping strength of the repair construct increases as the mechanical load increases. Although the newer linked double-row constructs have performed better biomechanically, limited clinical data currently exists demonstrating their superiority over single-row and traditional double-row repair. Preliminary biomechanical, clinical, and structural data suggest that double-row suture-bridging repair constructs are most likely to provide satisfactory results in most cases.

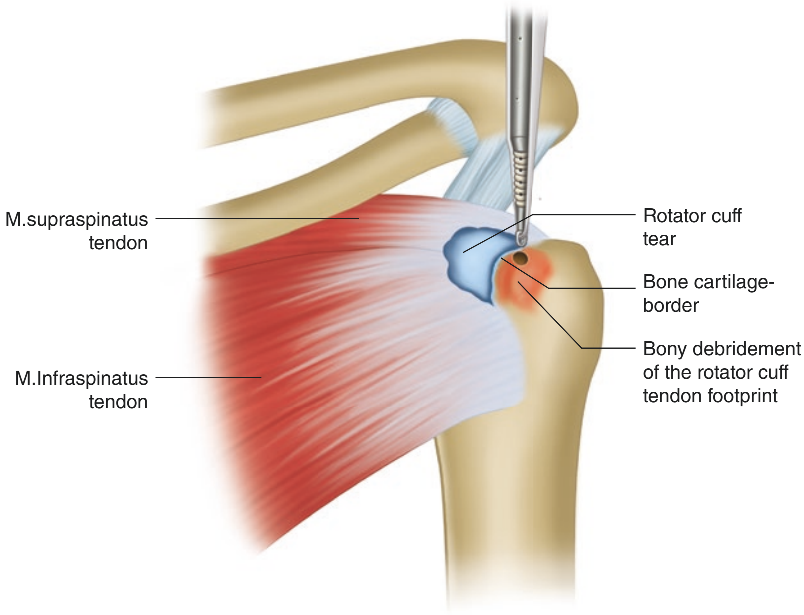

Fig. 4.6 Illustration depicting medial row anchor insertion in preparation for a double-row repair

Regardless of repair construct employed, the greater tuberosity needs to be prepared and cleared of residual soft tissue prior to any planned repair. This can frequently be accomplished with a combination of the radiofrequency probe, arthroscopic shaver, as well as 5.5 mm arthroscopic burr. Once the greater tuberosity and footprint have been adequately prepared, suture anchors can be placed at the desired location for repair. In a double-row construct, the most medial suture anchors are placed just lateral to the articular margin of the humeral head. An arthroscopic awl is used to create a pilot hole which is then subsequently filled with the suture anchor itself (Fig. 4.6).

The sutures from the suture anchor are then shuttled through the rotator cuff tendon with the help of one of a wide variety of suture-passing devices (Fig. 4.7).

The size and configuration of the rotator cuff tear as well as the planned fixation construct dictate both the number and position of the remaining suture anchors to be utilized. While some variables such as number of anchors and configuration are tear specific, the process of anchor insertion and suture passage through the rotator cuff tendon is universal (Figs. 4.8, 4.9, and 4.10).

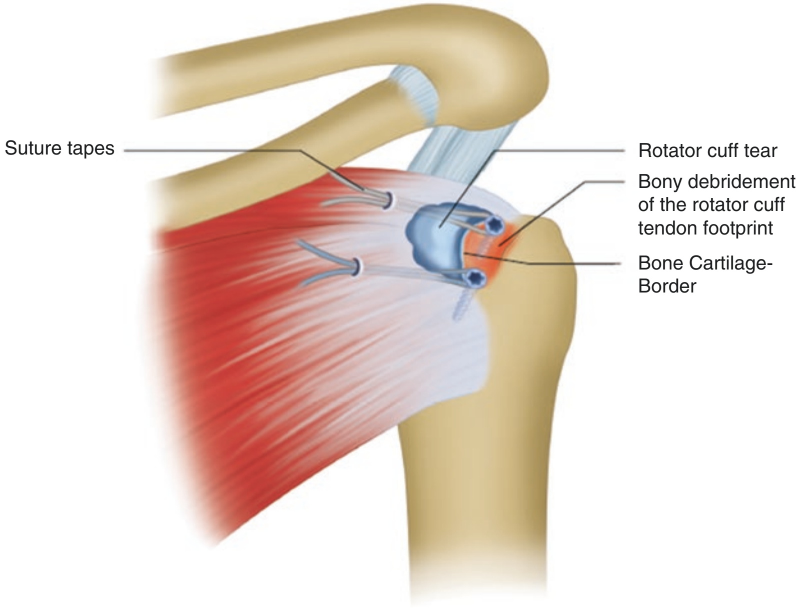

Fig. 4.7 Illustration depicting situs following suture tape passage through the rotator cuff

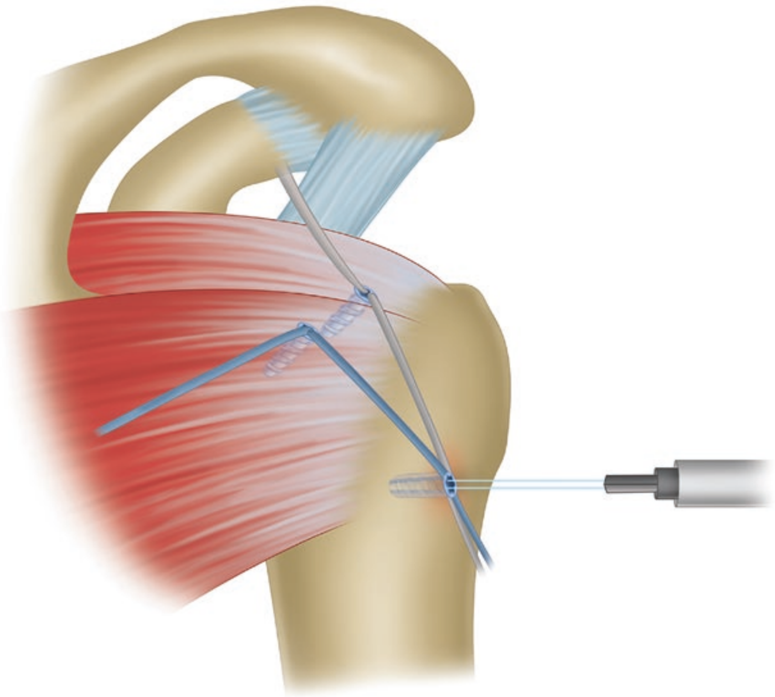

Fig. 4.8 Illustration depicting lateral-row anchor preparation

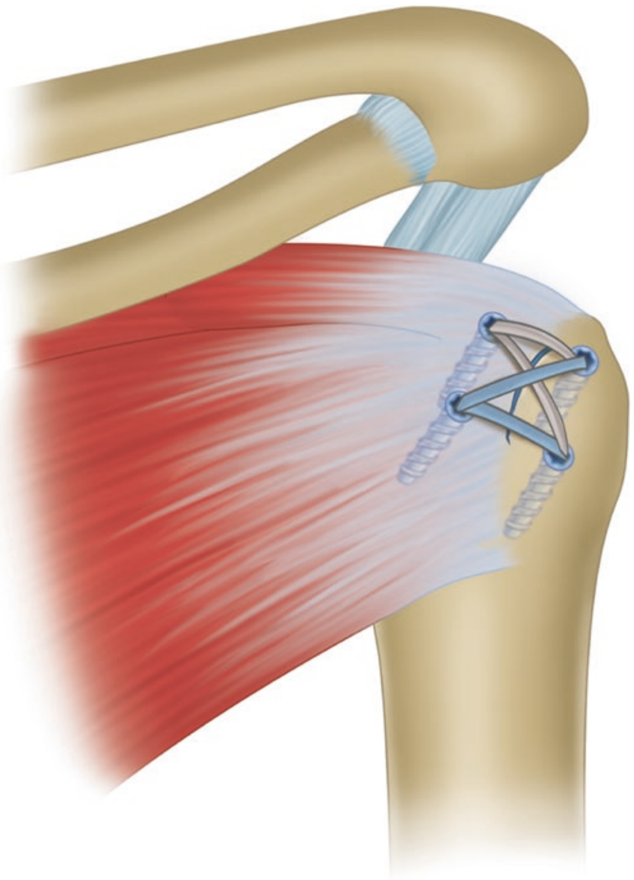

Fig. 4.9 Illustration depicting final double-row repair construct

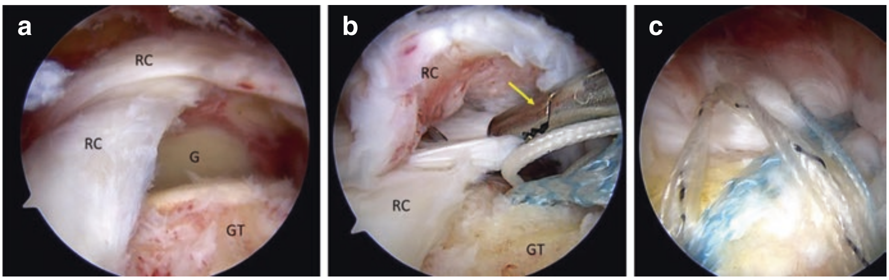

Fig. 4.10 Arthroscopic view of a left shoulder through the lateral portal demonstrating a delaminated postero-superior rotator cuff tear. (**a**) The delaminations of the rotator cuff (RC) are appreciated. (**b**) An arthroscopic grasper (arrow) is used to mobilize the deep lamination of the rotator cuff in preparation for repair. (**c**) The final double-row knotless construct is viewed here. G, glenoid; GT, greater tuberosity; RC, rotator cuff

Postoperative Rehabilitation

The postoperative rehabilitation protocol following a rotator cuff repair is highly variable, both among surgeons and also among patients and rotator cuff tears as well. Smaller, more stable crescent tears or even partial tears may be allowed more immediate range of motion. Larger tears are frequently restricted in their range of motion, sometimes for a period of 6–8 weeks postoperatively. In general, passive range of motion is initiated first, and active range of motion is initiated later, once interval healing of the cuff insertion has commenced.

Pearls and Pitfalls

Surgical step	Pitfalls	Pearls
Diagnostic arthroscopy	Missing concomitant lesions	Performing a thorough and standardized examination allows for identification of concomitant lesions
	Tear pattern recognition	Visualization of the rotator cuff tear through the lateral portal (bird's-eye or 50 yard line view) allows for proper rotator cuff tear recognition
Subacromial decompression	Excessive bleeding	Judicious use of the shaver during bursectomy near the scapula spine as this area is highly vascularized, consider radiofrequency ablation of bleeding vessels in this area
	Inadequate resection	Switching the arthroscope from the posterior to the lateral portal can help visualize both the amount and also regularity of acromial resection
Rotator cuff repair	Inadequate greater tuberosity preparation	Use a combination of a radiofrequency device, arthroscopic shaver, and arthroscopic burr to clear the greater tuberosity of all soft tissue to enhance healing rates of the repaired rotator cuff
	Excessive repair tension	Repair techniques are highly dependent on correct tear pattern identification. Margin convergence techniques should be employed for large U-, V-, L- or reverse L-shaped tears. Interval slides may be required for larger, immobile tears
	Tissue bridge formation	Judicious use of cannulas help with suture management and avoidance of tissue bridges at the site of rotator cuff repair
Postoperative rehabilitation	Postoperative stiffness	Early passive and active range of motion is initiated immediately, depending on any concomitant procedures performed

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Repair with Patch Augmentation

5

Jonas Pogorzelski, Erik M. Fritz, and Peter J. Millett

Introduction/Background

Partial repair of massive rotator cuff tears was introduced as a way to restore the rotator cuff's axial force couple, even in the cases of an irreparable torn supraspinatus tendon. When the force couple is balanced, sufficient compression of the humeral head into the glenoid can be obtained, thus preventing superior translation of the humeral head. However, even though short-term outcomes are promising, clinical outcomes may deteriorate over time and thus might not be the ideal solution for young and active patients. An exception occurs in cases where the rotator cuff can be repaired to nearly normal status but with a short tendon or a tendon with increased tension at the tendon-to-bone interface. This is particularly common in revision surgeries. In those settings, augmentation of the repair with an allograft patch can be used to improve force distribution and help prevent early failure. Besides the mechanical function, patches can also be used to improve native tendon healing as they can be impregnated with growth factors and stem cells, which have shown to improve cellular ingrowth into the graft tissue in animal and early clinical studies.

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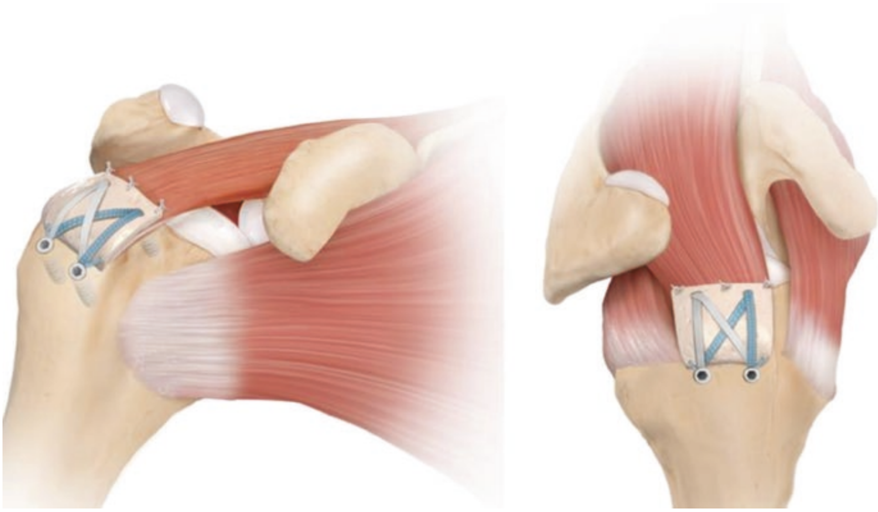

Fig. 5.1 Diagram demonstrating the final construct of a patch-augmented rotator cuff repair. The left panel is a frontal view and the right panel is an overhead view. The patch is on top of the tendon and both structures are secured medially and laterally to the footprint

Operative Principle

In general, the patch is used for augmentation and not bridging of a rotator cuff tear as the bridging technique is correlated with a high failure rate and unsatisfying outcomes in the literature. Augmentation means that the native rotator cuff tendon is secured to the medial footprint on the greater tuberosity with a human acellular dermal allograft patch placed over the top of the native cuff tendon. Subsequently, both structures, the tendon stump and the patch, are secured medially to the remaining rotator cuff tissue and laterally to the greater tuberosity with a knotless linked double-row construct (Fig. 5.1).

Indication

The decision to perform rotator cuff repair with patch augmentation is based on magnetic resonance imaging (MRI) appearance and intraoperative tendon quality and mobility. More precisely, it is indicated for patients with massive, retracted posterosuperior rotator cuff tears with poor tendon quality but good muscle quality (Goutallier <3) and where the tendon stump can be mobilized and repaired to nearly normal anatomy but with potentially increased tension at the tendon-to-bone interface.

Contraindications

Massive, retracted posterosuperior rotator cuff tears with degenerated and fatty-infiltrated muscle of Goutallier grade 3 or higher are usually irreparable and therefore should not be treated with a patch augmentation. Additionally, if the cuff tendon could not be sufficiently mobilized intraoperatively, other options such as tendon transfer, superior capsule reconstruction, or reverse total shoulder arthroplasty (rTSA) should be considered.

Technique

Preoperative Preparation

After the induction of general anesthesia and placement of a regional interscalene block, the patient is placed in the beach-chair position. The operative extremity is then situated in a pneumatic arm holder, and the operative shoulder and axilla are prepared and draped using standard sterile techniques.

Diagnostic Arthroscopy

A standard posterior viewing portal and an additional anterior working portal are routinely created. A 5-mm × 7-cm cannula is inserted in the anterior working portal and a probe inserted. After confirmation of a massive superior rotator cuff tear (Fig. 5.2), the remaining rotator cuff tissue is debrided to stable margins. If biceps tendon or its origin is injured, an arthroscopic biceps tenotomy is subsequently performed in anticipation of later tenodesis.

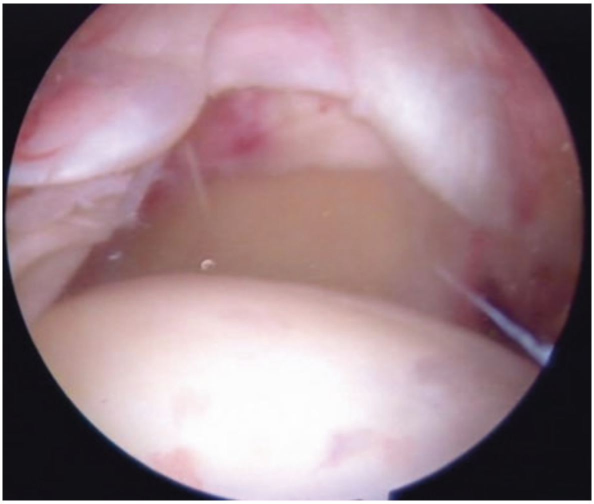

Fig. 5.2 Arthroscopic view of a right shoulder through a lateral portal demonstrating a massive irreparable rotator cuff tear of the supraspinatus and infraspinatus tendon

Subacromial Decompression and Acromioplasty

Once inspection and preparation of the glenohumeral joint is done, the arthroscope is next introduced into the subacromial space. If indicated, bursectomy, synovectomy, and subacromial spur removal can be performed using a 4.5-mm shaver and a 3.75-mm suction radiofrequency cautery device. The reconstruction of the superior rotator cuff can generally be done open or arthroscopically, depending on the surgeons' preference and the retraction of the tear.

Arthroscopic Technique

Previous suture anchors are removed where applicable, and the footprint at the greater tuberosity is then prepared with a motorized rasp to expose a bleeding surface to optimize healing of the later re-inserted tendon. Depending on the type of the tear, margin convergence or side-to-side techniques can be used to close the defects in the cuff tendons if necessary. Subsequently, the remaining native tendon stump is secured by the medial row of anchors. Typically, a knotless cross-linked double-row repair with four to six suture anchors is performed (Fig. 5.1). An arthroscopic punch is used to create a bone socket to accommodate the postero-medial anchor approximately 1–2 mm lateral to the articular bone-cartilage margin. A vented 4.75-mm knotless suture anchor loaded with suture tape and additional non-absorbable suture is subsequently placed in this postero-medial socket. Depending on the size of the rotator cuff tear, this step is repeated towards anterior until a sufficient number of medial anchors are placed. Afterward, an arthroscopic ruler is used to measure the area of tendon loss, which corresponds to the required dimensions of the allograft patch. At a back table, a 3.5-mm-thick human acellular dermal allograft patch is then incised along its long edge, thereby reducing the graft width according to previously performed measurements of the size of the defect (Fig. 5.3). Of note, the dermal allografts are generally used as tendon augments to reinforce the native

Fig. 5.3 A 3.5-mm-thick human acellular dermal patch is ex vivo cut along its long edge according to previously performed measurements of the size of the rotator cuff defect

rotator cuff tissue and are not used to bridge tendon defects. In this way the graft acts to reinforce the repair and acts as a bioscaffold for new tissue growth.

One strand each of the nonabsorbable suture and the suture tape are passed through the medial cuff remnant approximately 5 mm medial to the tear edge using a standard shuttling device. Each limb of suture and suture tape is retrieved and pulled through the anterolateral portal. The suture tapes are then passed through the medial region of the patch allograft ex vivo according to its planned in vivo positioning while maintaining a distance of at least 5 mm from its cut edges (Fig. 5.1). With the arthroscope in the posterior portal, the patch is introduced into the subacromial space through the anterolateral portal following the path of the suture tapes, which guides the patch allograft into the correct position on the medial cuff remnant. Using the previously loaded nonabsorbable sutures tied over the allograft in a horizontal mattress configuration, the remnant medial cuff tissue is reduced and secured to the greater tuberosity together with the patch allograft. The planned sites for lateral row anchor placements are then marked using a radiofrequency ablator as described above. An arthroscopic punch is again used to prepare the bone sockets laterally. One limb of suture tape from each medial anchor is retrieved and loaded into another knotless suture anchor which is subsequently driven into the first lateral bone socket. The suture tapes are then pulled to achieve adequate tension, thus reducing the patch allograft laterally and completely covering the greater tuberosity footprint. Finally, the suture tails are then cut, and the procedure is repeated as necessary using the remaining limbs of suture tape from each medial anchor (Fig. 5.4).

To finish the construct, two margin convergence sutures are then placed at the lateral part of the superior aspect of the graft into the leading edge of the supraspinatus tendon that can be identified in the recess of the glenohumeral joint. In general, care is taken to leave the rotator interval open. Multiple side-to-side sutures are subsequently placed along the medial aspect of the graft to secure it into native cuff tissue to provide additional stabilization. All suture tails are cut and the wound is thoroughly irrigated.

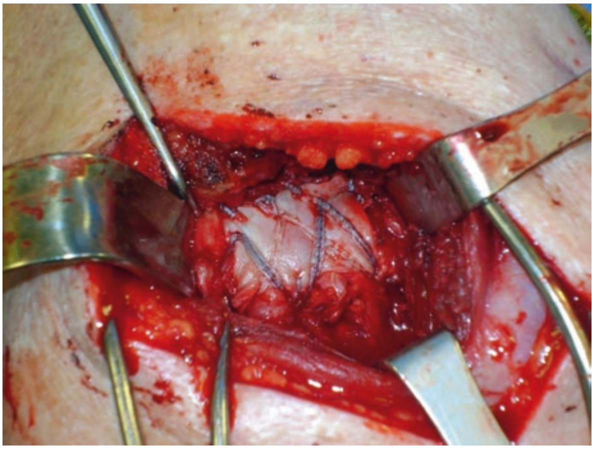

Fig. 5.4 Right shoulder following an open anterolateral approach demonstrating the final construct for augmented rotator cuff repair

Open Technique

If the tear needs extensive mobilization, an open standard deltoid-splitting approach can be used. Therefore, an anterolateral approach between the anterior and middle heads of the deltoid is performed, extending approximately 4 cm distally from the acromial tip. The deltoid is then partially taken down anteriorly from the acromion, and generally an acromial osteotomy is avoided. Multiple retractors are used to deflect the two heads of the deltoid muscle and thus provide sufficient view into the subacromial space. All further steps are similar as described above.

Postoperative Rehabilitation

In general, patients are protected postoperatively in a sling for 6–8 weeks. Moreover, shoulders are immobilized for 2 weeks followed by the initiation of passive motion exercises. To gradually increase shoulder range of motion, a limitation of 30° of external rotation, 90° of abduction, and 120° of forward flexion is typically implemented from weeks 2 through 6. At 6 weeks after surgery, active and active-assisted range of motion is allowed with stepwise strengthening exercises starting at 8 weeks. In contrast to active motion of the wrist and hand, flexion of the elbow against resistance was not allowed for 6 weeks postoperatively in patients who underwent biceps tenodesis.

Pearls and Pitfalls

Surgical steps	Pitfalls	Pearls
Diagnostic arthroscopy	Missing concomitant lesions.	Performing a thorough and standardized examination allows for identification of concomitant lesions.
Mobilization of the rotator cuff	Insufficient release and poor debridement of tendons laterally may lead to poor healing. Overly aggressive release may lead to traction damage to the suprascapular nerve and compromised blood supply.	If complete footprint coverage with native rotator cuff after debridement cannot be achieved, consider patch augmentation.
Medial-row anchor insertions	Dog-ear formation in case of asymmetrical anchor placement.	The surgeon should start with the anterior and posterior anchors and work from outside in if more than two medial anchors are necessary.
Preparation of the allograft patch according to defect size and suture passage	Incorrect size measurement, resulting in a graft that is too large or too small.	Use of an arthroscopic ruler beforehand.

Surgical steps	Pitfalls	Pearls
Introduction of patch	Suture derangement.	Arthroscopic visualization from the posterior portal and patch introduction through an anterolateral portal with an arthroscopic knot pusher.
Lateral-row anchor insertions and fixation	Insufficient room.	A radiofrequency device can be used to mark the location for the anchors to be inserted.
	Soft bone.	Assess bone quality with a punch. If the bone is soft, a 5.5 mm instead of a 4.75 mm anchor should be used.
	Dog-ear formation.	The surgeon should start with the anterior and posterior anchors and work from outside in if more than two lateral anchors are necessary.
Postoperative rehabilitation	Postoperative stiffness.	Early passive motion exercises starting from week 3. Progression to full passive motion and start of active and active-assisted motion at 6 weeks postoperatively.

Recommended Literature

1. Millett JP, Hussain ZB, Fritz EM, Warth RJ, Katthagen JC, Pogorzelski J. Rotator cuff tears at the musculotendinous junction: classification and surgical options for repair and reconstruction. Arthrosc Tech. 2017;6(4):e1075–85.
2. Petri M, Greenspoon JA, Moulton SG, Millett PJ. Patch-augmented rotator cuff repair and superior capsule reconstruction. Open Orthop J. 2016;10:315–23.

Latissimus Dorsi Transfer with Patch Augmentation

6

Jonas Pogorzelski, Erik M. Fritz, and Peter J. Millett

Introduction/Background

Massive and irreparable rotator cuff tears (RCTs) involving the postero-superior rotator cuff are a challenge for the surgeon as treatment options are generally limited. Limited implant longevity and activity restrictions for high-impact activities make reverse total shoulder arthroplasty a less desirable option in young and active patients. Latissimus dorsi transfer (LDT) with patch augmentation is a salvage procedure for the treatment of irreparable superior RCTs in young patients. During normal function, the latissimus dorsi muscle acts to adduct, internally rotate, and extend the humerus and extend the humerus. Contrary to its original function and due to its high adaptability, the latissimus dorsi muscle can be trained to act as humeral head depressor. Furthermore, its large muscle excursion makes it an ideal candidate for muscle transfer. As a result, the axial and coronal force couples are restored improving glenohumeral function and leading to pain relief. As a biofeedback program needs to be initiated postoperatively to achieve good outcomes, patient selection is crucial. Finally, long-term results of this procedure have been satisfactory.

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Operative Principle

The tendon of the latissimus dorsi is transferred from its insertion on the bicipital groove to the greater tuberosity, allowing the transferred tendon to close the posterosuperior rotator cuff defect and to act as a humeral head depressor. To avoid excessive tension at the tendon-bone-interface, an allograft patch can be used to extend the harvested tendon. As a result, the axial and coronal force couples are restored improving glenohumeral function and leading to pain relief.

Indication

LDT is indicated in patients with massive irreparable tear of the supraspinatus tendon or supraspinatus/infraspinatus tendons. Specifically, young and active patients, typically under the age of 65 with Hamada classification grades 1–3, are good candidates as reverse total shoulder arthroplasty (RTSA) is not ideal in this population due to limited implant longevity and activity restrictions for high-impact activities.

Contraindications

LDT should not be performed in patients with destroyed axial force couple, which is indicated by an irreparable subscapularis tendon lesion (positive belly press/lift-off test) or an irreparable teres minor tendon lesion (positive Hornblower's sign). Patients with significant rotator cuff tear arthropathy (Hamada classification grades 4–6) also should not undergo LDT. Finally, as with all elective surgeries, significant general medical comorbidities including cardiac disease, pulmonary disease, and active infection are contraindications to SCR. As a biofeedback program needs to be initiated postoperatively to achieve good outcomes, patients with limited physical coordination abilities should not be treated with LDT.

Technique

Preoperative Preparation

After the induction of general anesthesia and placement of a regional interscalene block, the patient is placed in the modified beach-chair position. The operative extremity is then situated in a pneumatic arm holder, and the operative shoulder and axilla are prepared and draped using standard sterile techniques.

Diagnostic Arthroscopy

A standard posterior and a standard anterior working portal are created. Afterward, a low-profile cannula is inserted in the anterior working portal, and a diagnostic arthroscopy is performed. An accessory lateral portal is created to mobilize the remaining scarred rotator cuff tendon with a suction radiofrequency cautery device. After confirmation of an irreparable rotator cuff tear via diagnostic arthroscopy, the remaining rotator cuff tissue is debrided to stable margins.

Deltoid-Splitting Approach

A deltoid-splitting approach (Fig. 6.1) between the anterior and middle heads over the acromion is performed, and the remaining rotator cuff is tagged with sutures to allow for manipulation.

Posterolateral Approach and Harvest of the Tendon

To harvest the latissimus dorsi tendon, the arm is elevated about 90°, and a curvilinear incision is made posteriorly and laterally (Fig. 6.1). Afterward the muscle belly is freed from attachments under protection of the neurovascular pedicle, and the tendon itself is detached from the humerus (Fig. 6.2). Once harvested, the tendon is augmented (Fig. 6.3) with a human acellular dermal patch, which is sewn in with locking stiches. Care must be taken that the patch extends medially allowing later the connection of the remaining rotator cuff tendon stump with the graft.

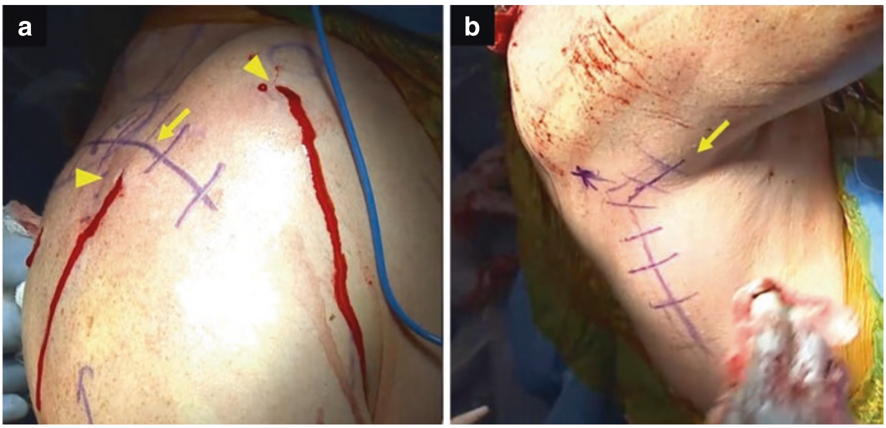

Fig. 6.1 View of a right shoulder prior to latissimus dorsi tendon transfer. (**a**) The incision is marked (arrow) for the deltoid-splitting approach. Note the presence of arthroscopy portals (arrowheads) as diagnostic arthroscopy has already been performed to confirm the irreparability of the rotator cuff. (**b**) The curvilinear mark (arrow) is made for the posterior and lateral incision where the latissimus dorsi tendon will be harvested

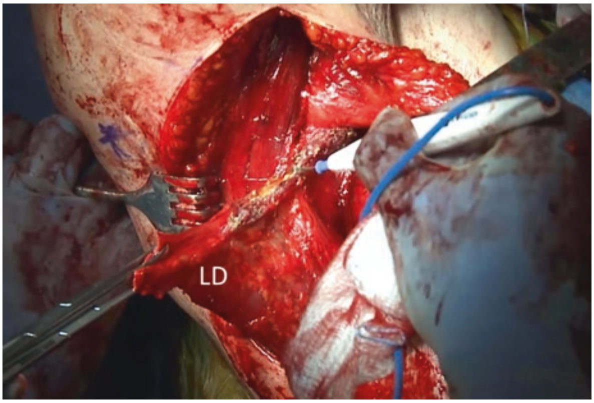

Fig. 6.2 View of the right upper extremity posterolateral incision demonstrating the latissimus dorsi (LD) tendon harvest prior to tendon transfer

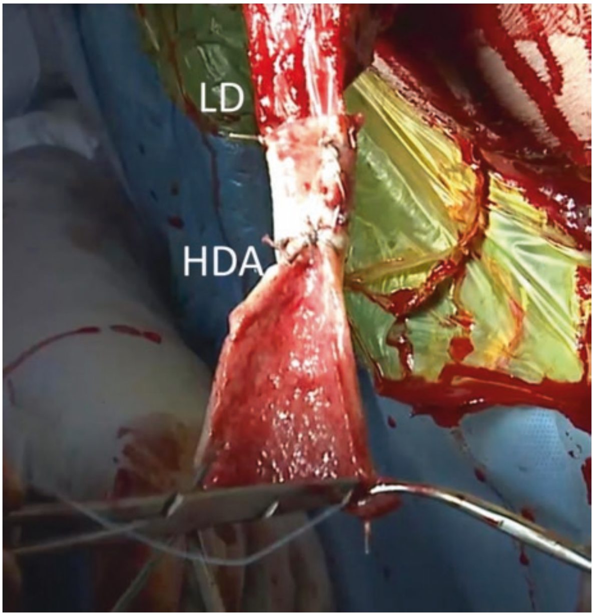

Fig. 6.3 View of the augmentation of the right-sided latissimus dorsi tendon (LD) with a sewn-in human acellular dermal allograft (HDA)

Passage of the Latissimus Dorsi Tendon/Patch Unit

After sufficient mobilization, the tendon/patch unit is subsequently shuttled underneath the deltoid muscle and posterior to the teres minor muscle into the subacromial space (Figs. 6.4 and 6.5).

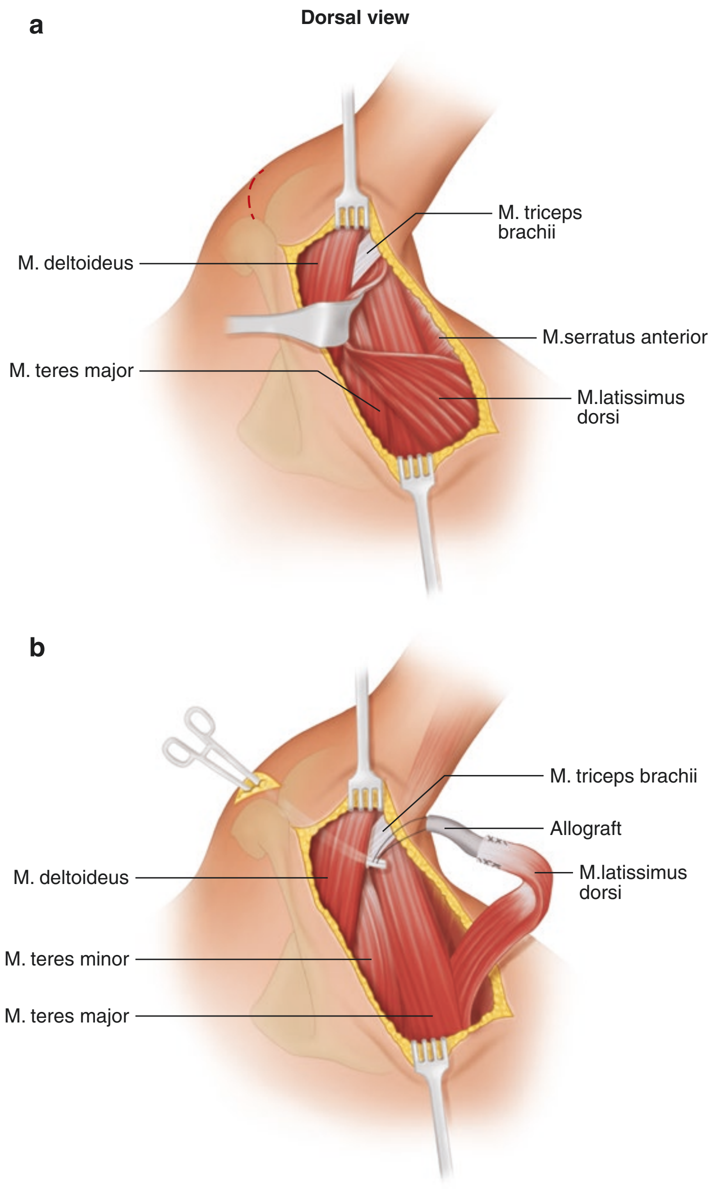

Fig. 6.4 Illustration demonstrating the steps of a right-sided allograft-augmented latissimus dorsi tendon transfer. (**a**) View of the right upper extremity posterolateral incision demonstrating the latissimus dorsi tendon harvest prior to tendon transfer. (**b**) View of the harvested and augmented right-sided latissimus dorsi tendon with human acellular dermal allograft. (**c**) Demonstration of the passage of the augmented tendon deep to the deltoid and posterior to the teres minor within the subacromial space; adequate length and tension are verified. (**d**) Illustration with other muscles removed demonstrating the new insertion of the augmented latissimus dorsi tendon on the greater tuberosity of the humerus

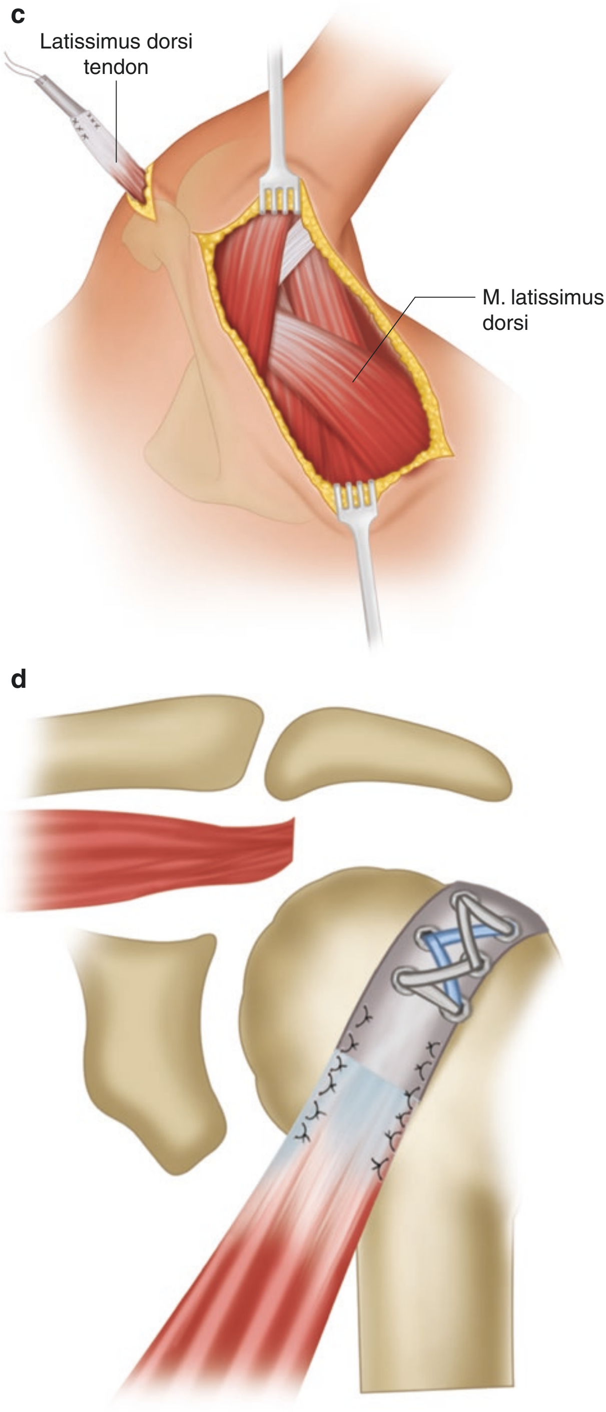

Fig. 6.4 (continued)

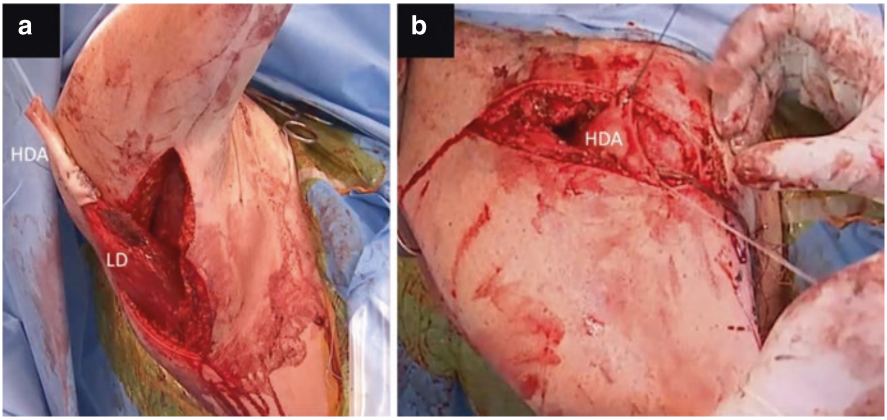

Fig. 6.5 View of the right upper extremity demonstrating passage of the augmented latissimus dorsi tendon. (**a**) Following augmentation of the latissimus dorsi (LD) with the human acellular dermal allograft (HDA), the tendon demonstrates sufficient length and mobilization. (**b**) The tendon/graft unit is subsequently shuttled underneath the deltoid muscle and posterior to the teres minor in the subacromial space

Fixation of the Latissimus Dorsi Tendon/Patch Unit

Depending on the size of the width of the latissimus dorsi tendon/patch unit, 6–8 cinch sutures are sewn into the patch and used to tension the tendon/patch unit laterally (Fig. 6.6). Next, a bleeding surface is created on the footprint to release biologic factors which may improve the healing of the tendon/patch unit. Afterward, it is fixed with an extended knotless double-row repair. Therefore, three to four medial row anchors loaded with tape are placed at the bone-cartilage margin at the greater tuberosity. All six to eight strands of the tape are shuttled through the patch and the latissimus dorsi tendon and are subsequently incorporated into a lateral row of three or four anchors in a crossing technique, thus compressing the tendon/patch unit onto the footprint. Finally, the tendon/patch unit is secured to the remaining native rotator cuff tendon posteriorly and the subscapularis tendon anteriorly (Fig. 6.7). Care must be taken to leave the rotator interval open. After thorough irrigation, all wounds are then closed in standard fashion.

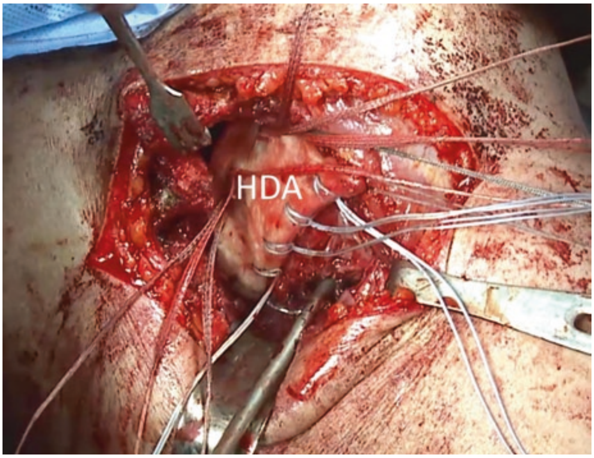

Fig. 6.6 View of the right upper extremity through the deltoid-splitting incision demonstrating the placement of cinch sutures through the allograft (HDA)

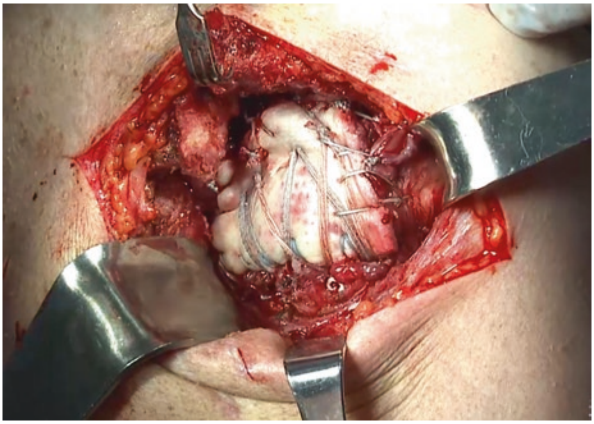

Fig. 6.7 View of a right shoulder through the deltoid-splitting incision demonstrating the completed latissimus dorsi tendon transfer secured with an extended knotless double-row fixation construct

Pearls and Pitfalls

Surgical step	Pitfalls	Pearls
Diagnostic arthroscopy	Missing concomitant lesions	Performing a thorough and standardized examination allows for identification of concomitant lesions
Deltoid-splitting approach	The axillary nerve runs transversely 5–7 cm distal to the edge of the lateral acromion	The split should not be extended further than 5 cm to avoid injury to the axillary nerve
Posterolateral approach and harvest of the tendon	Insufficient mobilization of the tendon and muscle belly	The muscle-tendon unit is mobilized until the tendon can reach the acromion. The neurovascular pedicle is identified and thoroughly freed

Surgical step	Pitfalls	Pearls
Passage of the latissimus dorsi tendon/patch unit	Insufficient space under the deltoid muscle and posterior of the teres minor muscle	A dilator is used to create a soft-tissue tunnel and a passing suture is placed through the dilator
Fixation of the latissimus dorsi tendon/patch unit	Insufficient length of latissimus dorsi tendon leading to over-tensioning	Augmentation of the transferred tendon with a 3-mm ArthroFlex patch

Postoperative Management

Immediately following surgery, patients are strictly immobilized in an abduction pillow for 6 weeks. The rehabilitation goals of these first 6 weeks include protecting the surgical repair, minimizing pain and inflammation, maintaining mobility of accessory joints (fingers, wrist, elbow), and providing patient education. After 6 weeks, the patient is cleared by the surgeon to begin full passive range of motion as well as active range of motion of the glenohumeral joint without restrictions other than patient tolerance. A biofeedback program is initiated, teaching the patient how to activate the latissimus dorsi muscle for forward flexion and external rotation of the shoulder. The muscular strength phase is generally introduced at 10–12 weeks postoperatively and consists of progressive resisted ROM and initial closed chain exercises. After 3 months, and as patients continue to build strength, treatment is focused on progressing endurance with daily activities as well as work and recreational activities at or below shoulder height.

Recommended Literature

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Arthroscopic Superior Capsule Reconstruction

7

Jonas Pogorzelski, Erik M. Fritz, and Peter J. Millett

Introduction/Background

Massive and irreparable rotator cuff tears (RCTs) involving the (postero-)superior rotator cuff are a challenge for the surgeon as treatment options are limited. While reverse shoulder arthroplasty is indicated for patients with advanced cuff arthropathy, limited prosthetic implant longevity and activity restrictions for high-impact activities make it a less desirable option in young patients. Arthroscopic superior capsule reconstruction (ASCR) is a minimally invasive surgical technique for the treatment of patients suffering from pain-induced pseudoparalysis of the shoulder due to an irreparable superior RCT. Advantages of ASCR over alternative joint-preserving procedures include better approximation of the native anatomy, decreased invasiveness, and the potential for easier future surgical revisions.

Operative Principle

The implantation of an acellular human dermal allograft replaces the torn superior rotator cuff tendon and acts as the superior capsule, thus preventing the humeral head from migrating superiorly by acting as a static restraint (Illustration 7.11). This

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surgery alters shoulder biomechanics thereby centering the humeral head during abduction and forward flexion, preventing superior escape, and leading to additional pain relief.

Indication

ASCR is indicated in patients suffering from pain-induced pseudoparalysis of the shoulder due to a massive irreparable tear of the supraspinatus tendon and who are young and active, typically under 65 years of age, with a minimal cuff arthropathy Hamada classification grades 1–3.

Contraindications

ASCR should not be performed in patients with a destroyed axial force couple, which is indicated by an irreparable subscapularis tendon lesion (positive belly press/lift-off test) or teres minor tendon lesion (positive Hornblower's sign). Patients with significant rotator cuff tear arthropathy (Hamada classification grades 4–6) also should not undergo SCR. Finally, as with all elective surgery, significant general medical comorbidities including cardiac disease, pulmonary disease, and active infection are contraindications to SCR.

Relative contraindications include less than 3/5 forward flexion strength as this can be a potential risk factor for suboptimal postoperative outcomes.

Technique

Preoperative Preparation

After the induction of general anesthesia and placement of a regional interscalene block, the patient is placed in the beach-chair position. The operative extremity is then situated in a pneumatic arm holder, and the operative shoulder and axilla are prepared and draped using standard sterile techniques.

Diagnostic Arthroscopy

Standard posterior, anterior working, anterolateral, lateral, and posterolateral portals are created. A 5-mm × 7-cm cannula is inserted in the anterior working portal and a 12-mm × 3-cm cannula is inserted in the anterolateral portal. After confirmation of an irreparable rotator cuff tear (Fig. 7.1) via diagnostic arthroscopy, the remaining rotator cuff tissue is debrided to stable margins, and the dimensions of the defect are measured in both the sagittal and coronal planes (Fig. 7.2).

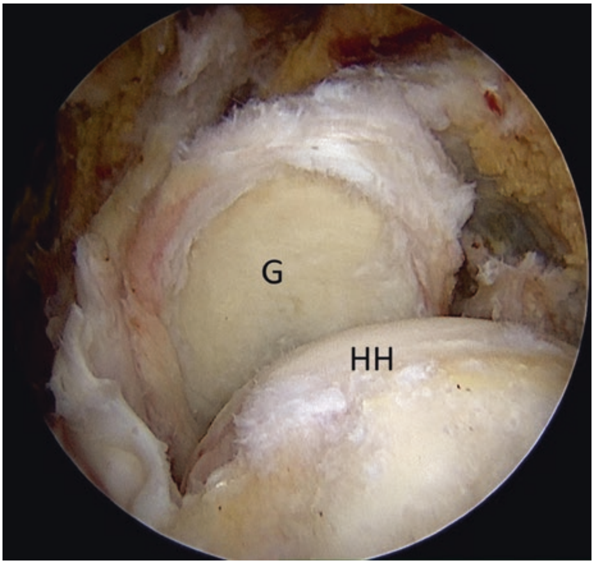

Fig. 7.1 Arthroscopic view of a right shoulder through the lateral portal demonstrating a massive irreparable posterosuperior rotator cuff tear. *G*, glenoid; *HH*, humeral head

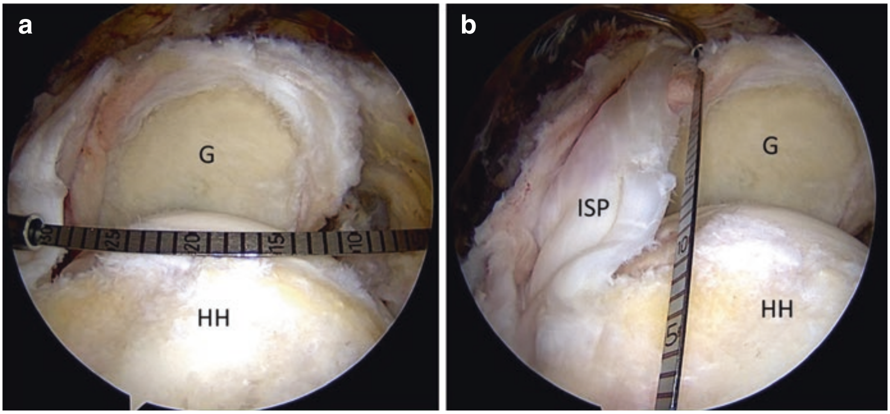

Fig. 7.2 Arthroscopic view of a right shoulder through the lateral portal measuring the size of the cuff defect. (**a**) Measurement from anterior to posterior. (**b**) Measurement from medial to lateral. G, glenoid; *HH*, humeral head; *ISP*, infraspinatus

Placement of the 12 o'clock Anchor

A Neviaser portal is then established, and the first 3.0 mm suture anchor is placed at the 12 o'clock position on the glenoid just medial to the labrum (Fig. 7.3). Both suture limbs are then shuttled out through the anterolateral portal.

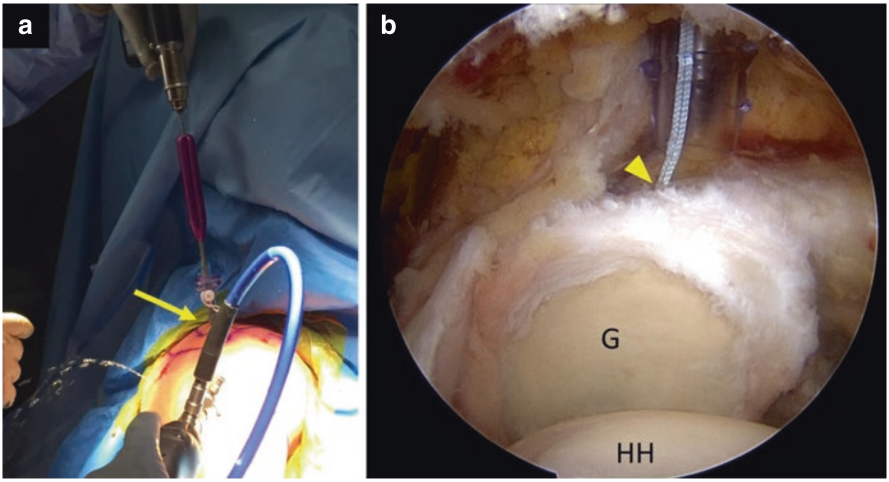

Fig. 7.3 (**a**) With the arthroscope in the lateral portal of the right shoulder, a bone socket is drilled via the Neviaser portal (arrow) into the glenoid for subsequent placement of the 12 o'clock suture anchor. (**b**) Arthroscopic view through the lateral portal of the right shoulder following placement of the 12 o'clock suture anchor (arrowhead) into the glenoid. *G*, glenoid; *HH*, humeral head

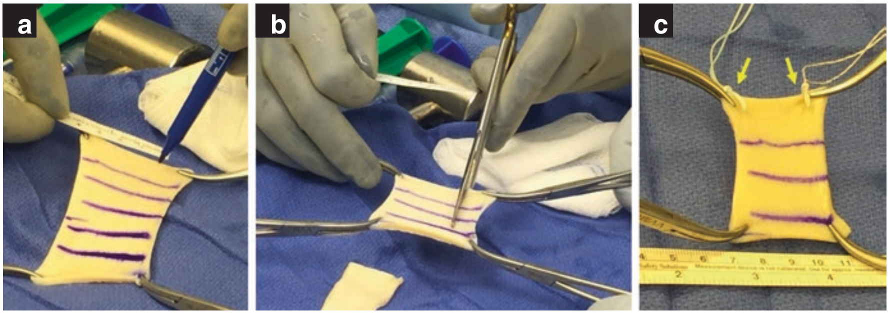

Fig. 7.4 (**a**) Preparation and measurement of the human acellular dermal allograft with the superior side marked for intra-articular orientation. (**b**) The graft is cut to correct width and length. (**c**) Following preparation and cutting, the final graft is viewed here with cinch stitches (arrows) placed on the lateral side

Graft Preparation

Next, a 3.5-mm-thick human acellular dermal allograft patch is prepared and shaped according to the measured size of the defect ex vivo (Fig. 7.4). The sutures of the 12 o'clock anchor are shuttled ex vivo through the prepared graft using a suture shuttling device (Fig. 7.5). Two additional lateral cinch stiches are shuttled through the graft. Subsequently the cannula in the antero-lateral portal is removed, and the graft is then introduced into the shoulder with the help of a knot pusher

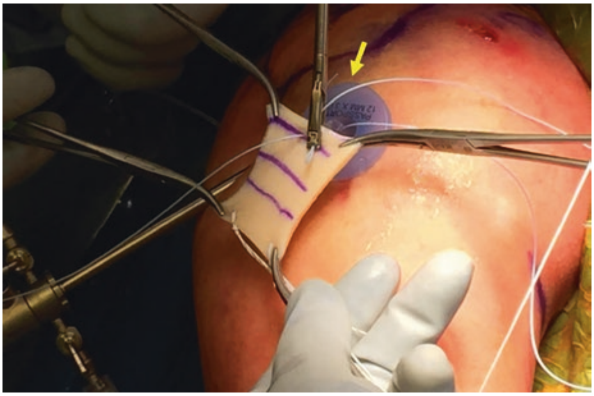

Fig. 7.5 Right shoulder. A cannula (arrow) is placed in the antero-lateral portal, and the limbs of the 12 o'clock glenoid suture anchor are pulled out by the cannula and passed through the middle medial border of the graft

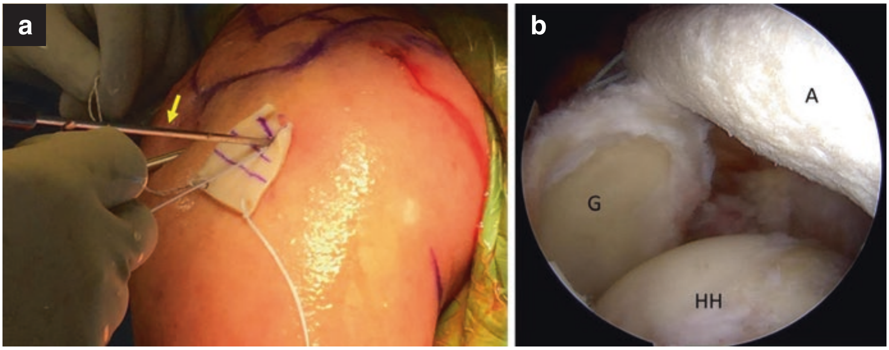

Fig. 7.6 Right shoulder. (**a**) The passport cannula is removed from the antero-lateral portal, and a knot pusher (arrow) is then used to pass the graft into the shoulder. (**b**) Intra-articular view through the posterolateral portal of the graft being passed into the shoulder. *A*, allograft; *G*, glenoid; *HH*, humeral head

(Fig. 7.6). Both limbs of the suture of the 12 o'clock anchor are then tied down to secure the graft medially.

Placement of the 2 and 10 o'clock Anchor

Subsequently, the antero-medial and postero-medial anchors in the 10 and 2 o'clock positions, introduced through the anterior and posterior standard portals, are placed. One limb of each suture of each anchor is shuttled through the graft with the help of a suture shuttling device. The second limb of each suture is placed next to the graft and finally tied down together with the first limb, which finalizes the medial fixation of the graft (Fig. 7.7). In general, three 3.0-mm suture anchors for medial fixation of the graft should be used. However, for larger tears and bigger glenoids, 3.5-mm knotless anchors loaded with tape can be used alternatively.

Placement of the Medial-Row Anchors at the Footprint

Afterwards, humeral fixation is prepared with a motorized rasp to expose a bleeding surface at the footprint to optimize healing. A medial row of typically two anchors loaded with tape is placed at the bone/cartilage interface at the greater tuberosity (Fig. 7.8). All limbs of the tapes are then shuttled through the graft. The additional eyelet suture of each anchor is used to fix the graft anteriorly with the subscapularis tendon and posteriorly with the infraspinatus tendon.

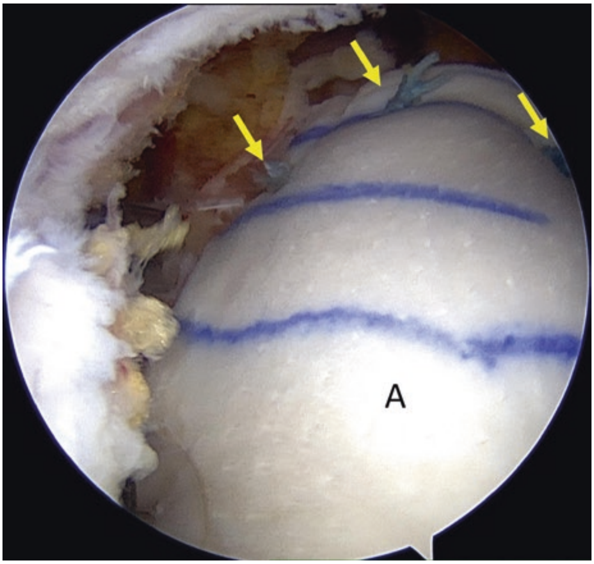

Fig. 7.7 Arthroscopic view of the right shoulder through the lateral portal demonstrating final medial fixation of the graft to the glenoid with three knotted suture anchors at the 10, 12, and 2 o'clock positions (arrows). *A*, allograft

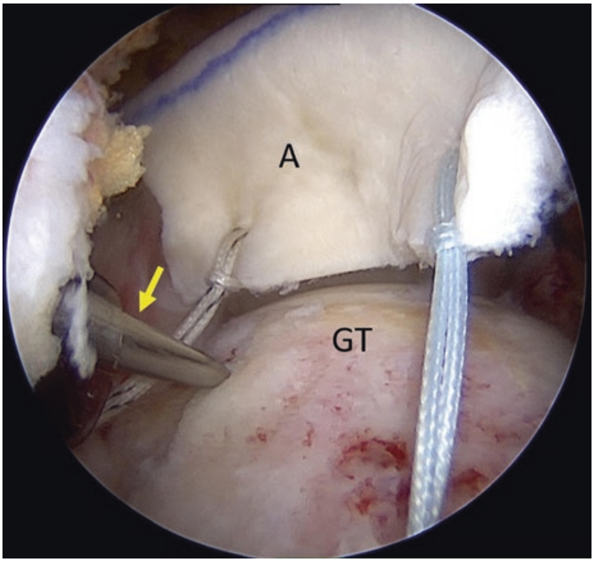

Fig. 7.8 Arthroscopic view of the right shoulder through the lateral portal demonstrating preparations for the lateral fixation of the graft to the greater tuberosity. An arthroscopic punch (arrow) is positioned to create a bone socket for subsequent medial-row suture-anchor placement. *A*, allograft; *GT*, greater tuberosity

Placement of the Lateral Row Anchors at the Footprint

The graft is finally fixed laterally using a bridging double-row construct (Fig. 7.9), most commonly with a total of four suture anchors and with the shoulder in 0–10° abduction. For massive tears, an extended construct with 6–8 anchors should be used. The two previously placed cinch stitches are passed through the eyelets of the lateral anchors along with the suture tapes, thus incorporating the cinch stitches into the final anchor 7/tape construct; this has the benefit of compressing the edges of the graft onto the supraspinatus footprint. Side-to-side stiches secure the graft to the infraspinatus and subscapularis tendon while leaving the rotator interval open (Figs. 7.10 and 7.11).

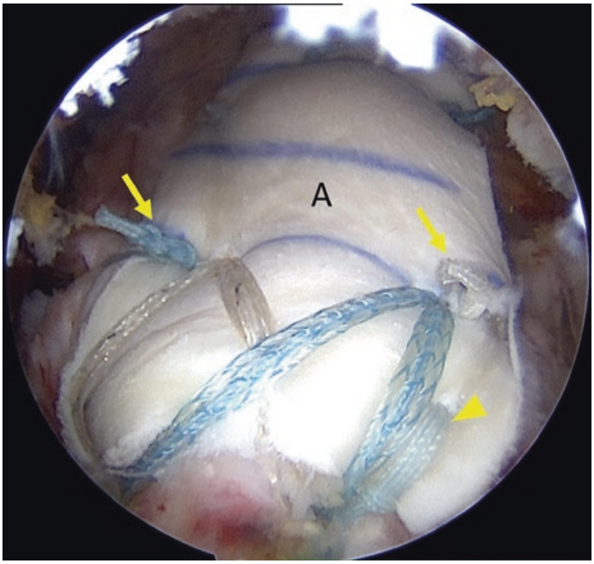

Fig. 7.9 Arthroscopic view of the right shoulder through the lateral portal demonstrating the final lateral fixation of the graft to the greater tuberosity. The two previously placed cinch stitches (arrowhead, only the anterior stitch visible here) are passed through the eyelets of the lateral anchors along with the suture tapes, thus incorporating the cinch stitches into the final SpeedBridge construct; this has the benefit of compressing the edges of the graft onto the supraspinatus footprint. Side-to-side stiches (arrows) secure the graft to the infraspinatus and subscapularis tendons (while leaving the rotator interval open)

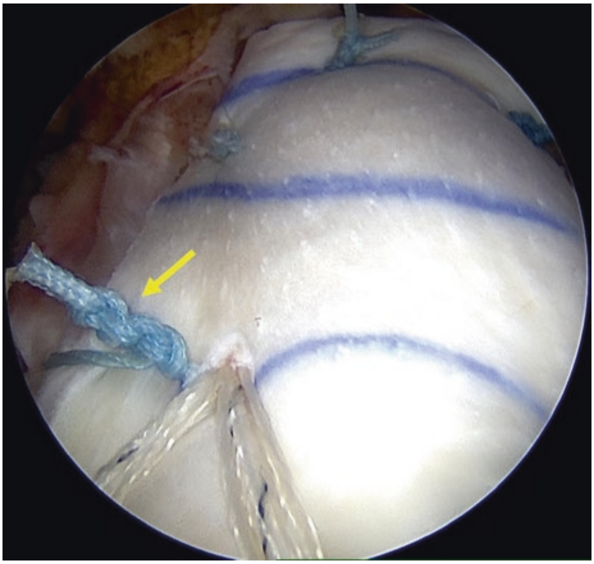

Fig. 7.10 Arthroscopic view of the right shoulder through the lateral portal demonstrating an additional side-to-side suture (arrow) placed in the infraspinatus

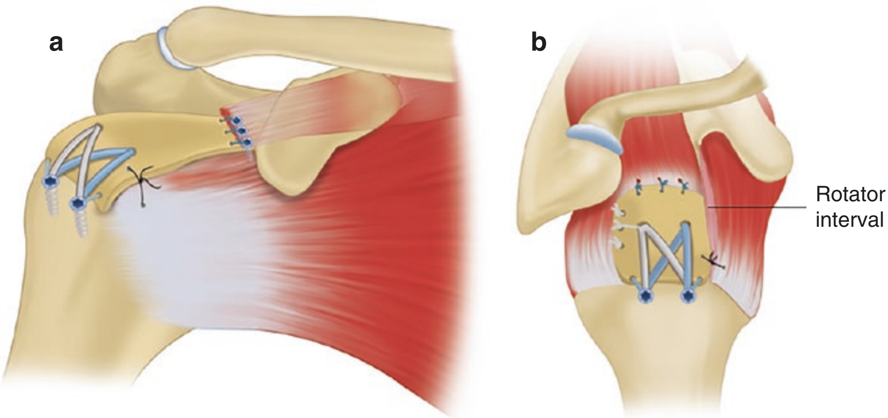

Fig. 7.11 Illustration of a right shoulder demonstrating the final superior capsule reconstruction construct from an anterior (**a**) and lateral (**b**) view. The medial end is fixed to the glenoid with three suture anchors, the lateral end is fixed to the greater tuberosity with a knotless double-row construct, and the posterior edge is secured to the infraspinatus tendon with multiple cinch stitches

Pearls and Pitfalls

Surgical step	Pitfalls	Pearls
Diagnostic arthroscopy	Missing concomitant lesions.	Performing a thorough and standardized examination allows for identification of concomitant lesions.
Glenoid-sided anchor insertions	Malpositioning of the anchors, with potential damage to the glenoid cartilage.	Insertion of the 12 o'clock anchor through the Neviaser portal in the supraclavicular fossa; the anterior and posterior anchor are inserted through the standard anterior and posterior portals.
Preparation of ArthroFlex patch according to defect size and suture passage with SutureLasso	Incorrect size measurement, resulting in a graft that is too large or too small.	Use of an arthroscopic ruler beforehand.
Introduction of patch	Suture derangement.	Arthroscopic visualization from the posterior portal and patch introduction through the antero-lateral portal with an arthroscopic knot pusher. Prior to the introduction, the cannula is cut lengthwise and removed.
Medial-row anchor insertions and fixation	Malpositioning of the anchors, with potential damage to the humeral cartilage or anchor pullout.	Placement of the medial-row anchors just lateral to the articular cartilage margin, respecting the deadman's angle of 45° or less, and minimum antero-posterior distance of 1–1.5 cm between the anchors.
Lateral-row anchor insertions and fixation	Insufficient room.	A radiofrequency device can be used to mark the location for the anchors to be inserted.
	Soft bone.	Assess bone quality with a punch. If the bone is soft, a 5.5-mm instead of a 4.75 mm suture anchor should be used.
	Dog-ear formation.	The surgeon should start with the anterior and posterior anchors and work from outside in if more than two lateral anchors are required. Additional cinch stiches in the edges of the graft which are finally introduced into the eyelet of the lateral-row anchors also help prevent dog-ear formation.

Postoperative Management

Immediately following surgery, patients are strictly immobilized in an abduction pillow for 6 weeks. The rehabilitation goals of these first 6 weeks include protecting the surgical repair, minimizing pain and inflammation, maintaining mobility of accessory joints (fingers, wrist, elbow), and providing patient education. After 6 weeks, the patient is cleared by the surgeon to begin full passive range of motion as well as active range of motion of the glenohumeral joint without restrictions other than patient tolerance. Rehabilitation of the shoulder at this point generally follows a rehabilitation program typical of a postoperative massive rotator cuff repair. The muscular strength phase is generally introduced at 10–12 weeks postoperatively and consists of progressive resisted ROM and initial closed chain exercises. After 3 months, and as patients continue to build strength, treatment is focused on progressing endurance with daily activities as well as work and recreational activities at or below shoulder height.

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8 Pectoralis Major Tendon Transfer for Irreparable Subscapularis Tears

Rafael Peçanha Pitta, Jonas Pogorzelski, Burak Altintas, Erik M. Fritz, and Peter J. Millett

Introduction/Background

Irreparable subscapularis tendon lesions can be caused by the evolution of degenerative pathology or more commonly from an initial traumatic event. The irreparability of these massive tears is determined by the degree of tendinous and muscular degeneration leading to distraction, fatty infiltration (stage 3 or more according to the Goutallier classification), and cranial migration of the humeral head with acromial-humeral interval <5 mm in the AP view. Clinically, patients with irreparable subscapularis lesions demonstrate weakness with internal rotation, mostly in combination with anterior pain. Pectoralis major tendon transfer is the treatment of choice for irreparable subscapularis tears. While multiple techniques of anterior capsular reconstruction (ACR) procedure have shown dissatisfying results, more recently surgeons have been using an ACR technique with human acellular dermal allograft with promising early results in young and active patients with irreparable subscapularis tears. However, since this is a new and as-yet unproven procedure,

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and since allografts are still not universally accessible, the transfer of the pectoralis major tendon is presented as a viable salvage procedure for these patients.

Operative Principle

The transfer of the upper 2/3 of the pectoralis major tendon attempts to not only recreate the force vector of the deficient subscapularis muscle-tendon unit but also rebalance of the axial plane force couple of the shoulder by creating an inferior and medially directed force vector on the humeral head, thus mimicking the natural function of the subscapularis. Depending on the size of the subscapularis tear and the size of the transferred pectoralis major muscle-tendon unit, this procedure can be performed by transferring the upper 2/3 of the pectoralis major tendon alone or in combination with the teres major muscle-tendon unit for larger tears. The teres major has a more posteriorly and inferiorly directed force vector that may be helpful in stabilizing larger tears.

Indications

The pectoralis major transfer is a salvage procedure indicated in young and active patients (<60–65 years) who present with irreparable subscapularis tears, most commonly after failed previous repairs. Patients should also have, at most, minimal osteoarthritis (Hamada classification <3) and good deltoid function to maintain abduction.

Contraindications

The pectoralis major transfer should not be performed in the presence of advanced osteoarthritis (Hamada classification ≥3). Another contraindication is static anterior or superior subluxation of the humeral head as confirmed by radiography. In patients with superior humeral head subluxation and inability to raise the arm overhead (< grade 3 motor function) with pseudoparalysis, a pectoralis major transfer will not restore forward elevation of the arm. Additional surgical contraindications include axillary nerve lesions or injury with consequent deltoid malfunction along with active infection.

Technique

Preoperative Preparation

The patient is placed in the beach-chair position under general anesthesia with an associated interscalene block. The operative extremity is then prepared and draped using standard sterile technique. Subsequently, the upper extremity is placed in a pneumatic arm holder which is used for intraoperative manipulation.

Approach and Tendon Mobilization

A diagnostic arthroscopy is first performed using a standard posterior viewing portal and a standard anterior working portal. The expected subscapularis tear is visualized, and after a 360° release, the tendon irreparability is determined according to the tendon retraction, size of the lesion, and tissue quality. If possible, the lower portion of the subscapularis muscle should be preserved or repaired to reduce the size of the tear. The long head of the biceps tendon is identified, and a tenotomy is performed for subsequent tenodesis at the end of the case.

The open procedure begins with an extended deltopectoral approach of approximately 10–12 cm to facilitate the exposure of the upper and lower borders of the pectoralis major muscle (Fig. 8.1). The incision starts just lateral to the coracoid process, and the cephalic vein is identified (Fig. 8.2) and retracted laterally together with the deltoid muscle. The adhesions around the humeral head and subcoracoid

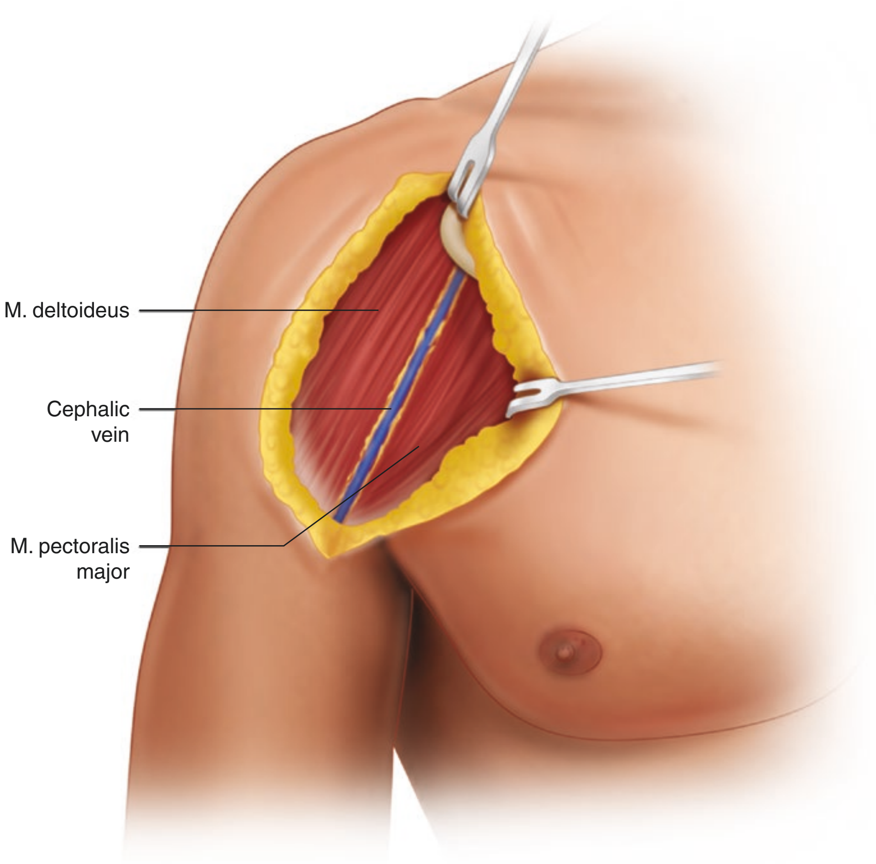

Fig. 8.1 Illustration of a right shoulder demonstrating an extended anterior deltopectoral approach of approximately 10–12 cm. The cephalic vein is shown between the deltoid (lateral) and pectoralis major (medial) muscles

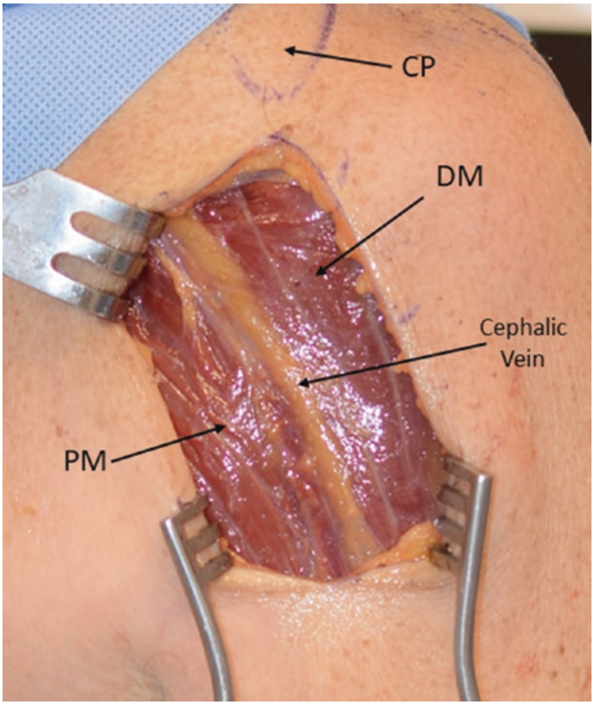

Fig. 8.2 Cadaveric demonstration of a left-sided pectoralis major tendon transfer for irreparable subscapularis tear. An extended anterior deltopectoral approach of approximately 10–12 cm is made to facilitate exposure of the pectoralis major muscle (PM). DM, deltoid muscle

region are released in order to expose the subscapularis lesion and the lesser tuberosity (Fig. 8.3). The axillary nerve should be visualized and protected medial to the conjoint tendon and close to the humeral neck just above the upper border of the pectoralis major tendon. Slight forward flexion of the arm in adduction can be helpful in identifying the nerve.

The identification and dissection of the upper and lower border of the pectoralis major are performed from lateral to medial, and the plane between the posterior part of the tendon and the humeral shaft is developed. The upper 2/3 of the pectoralis major tendon can be found easily at the humeral insertion (Fig. 8.4). The upper 2/3 are then sharply detached from the humeral shaft close to the bone (Fig. 8.5), and three modified Krakow stitches with number 5 nonabsorbable sutures are placed through the pectoralis major tendon (upper border, middle and lower border – Fig. 8.6). These sutures are used to transfer and manipulate the muscle-tendon unit. Different colors of suture can be used to avoid twisting of the muscle-tendon unit during the transfer.

Adhesions around the pectoralis major tendon and muscle belly are released to gain lateral and cranial excursion. Slight internal and external rotation of the arm can facilitate lateral dissection of the pectoralis major, while adduction with simultaneous external rotation of the arm improves medial visualization. Medial dissection should not exceed approximately 10 cm to avoid denervation of the muscle. Once the upper 2/3 of the pectoralis major tendon is appropriately

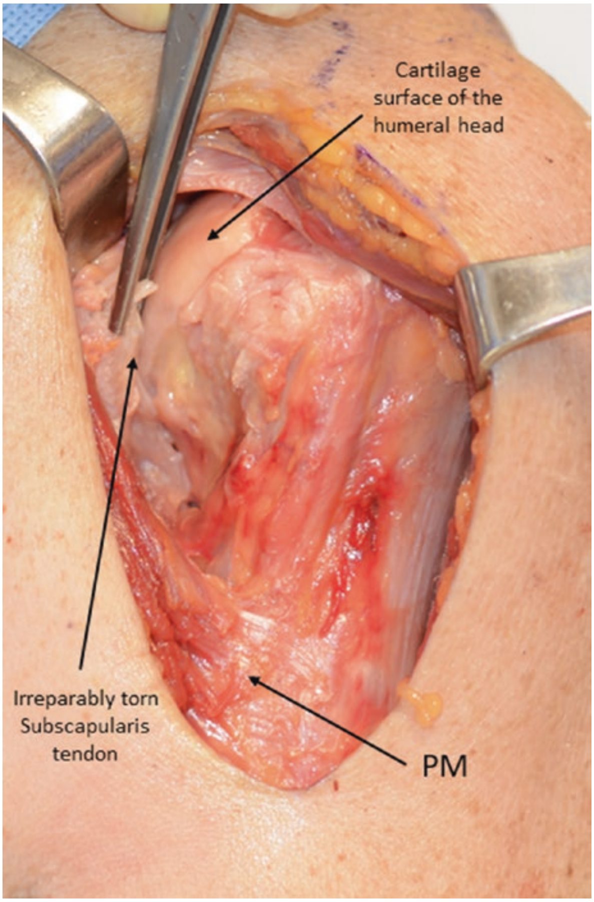

Fig. 8.3 After lateral retraction of the deltoid muscle, the complete pectoralis major (PM) tendon is visible. The irreparability of the subscapularis tear is confirmed intraoperatively

released, it is transferred to the original footprint of the subscapularis tendon (Fig. 8.7). Afterward, three holes for subsequent fixation of the transferred tendon are drilled with a 3.2 mm drill at the lateral border of the footprint. Subsequently, the transferred tendon is fixed to the bone (see below) using three biceps buttons (Fig. 8.8). To facilitate inserting, a button inserter can be used (Fig. 8.9).

Additional Teres Major Transfer

In case of a complete and irreparable rupture of the subscapularis tendon, a teres major transfer may be performed in addition to the aforementioned pectoralis major transfer. In general, the dissection of the teres major tendon is performed prior to fixation of the split pectoralis major. The arm is maximally externally rotated to

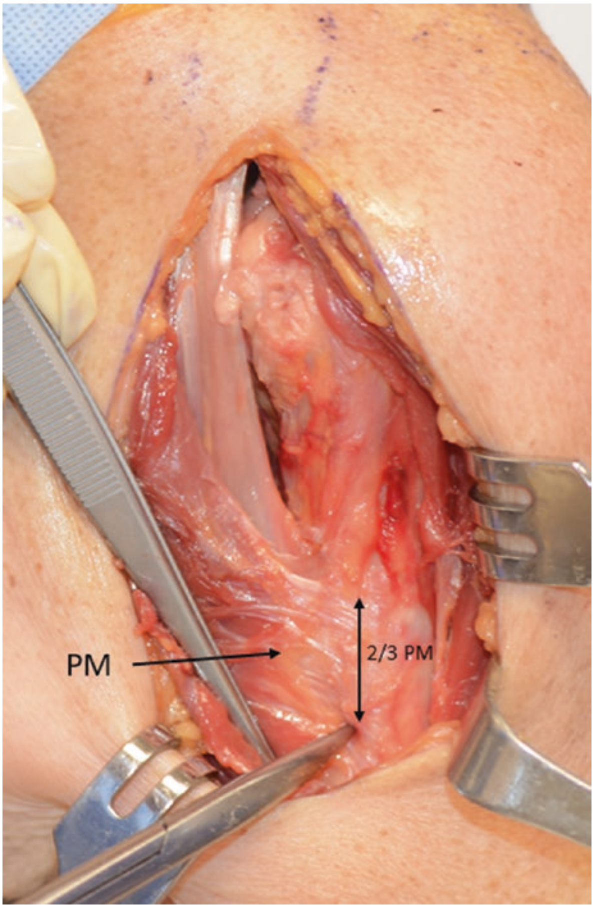

Fig. 8.4 The upper 2/3 of the pectoralis major (PM) tendon are marked

expose the common origin of the latissimus dorsi and teres major tendons. Subsequently, the latissimus dorsi tendon is carefully dissected and released from the humeral shaft to allow for better visualization of the teres major tendon. Approximately 1 cm of the latissimus dorsi tendon should be left on the humerus to allow for better refixation of the latissimus dorsi tendon at the end of the procedure. Once released, the latissimus dorsi tendon is reflected medially. The teres major tendon can then be elevated subperiosteally. The teres major tendon is typically quite short so two nonabsorbable sutures should be placed through the tendon (upper and lower border) in a Mason-Allen or Krakow configuration. The teres major tendon is then mobilized medially not to exceed approximately 7 cm to save the neurovascular pedicle. Finally, the latissimus dorsi tendon is refixated to the humeral shaft with connecting sutures between the previously left cuff of tendon, and the teres major tendon is transferred to the lower part of the lesser tuberosity.

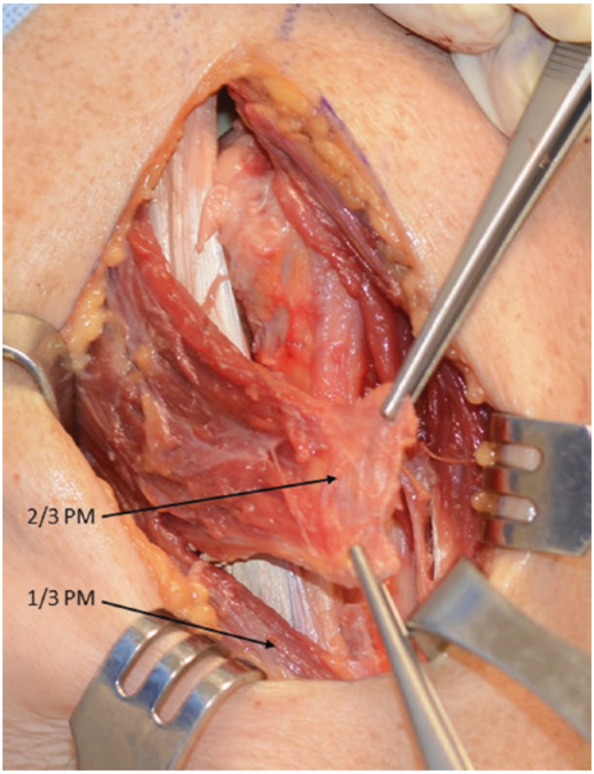

Fig. 8.5 Care must be taken to leave approximately 1/3 of the pectoralis major (PM) tendon attached to the humeral shaft

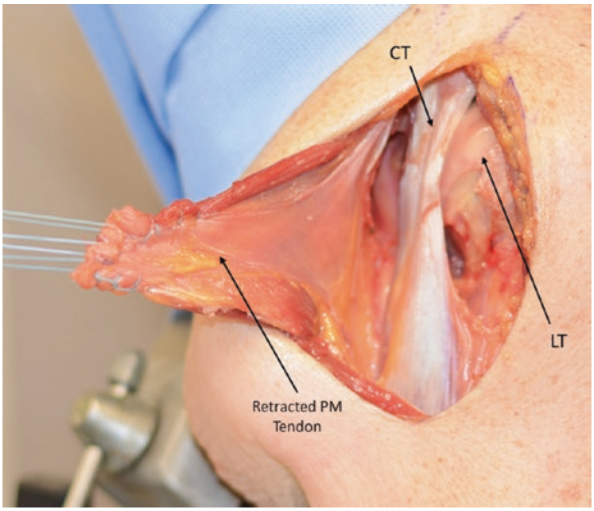

Fig. 8.6 Three modified Krakow stitches with number 5 nonabsorbable sutures are placed through the pectoralis major (PM) tendon (upper border, middle and lower border). CT, conjoint tendon; LT, lesser tuberosity

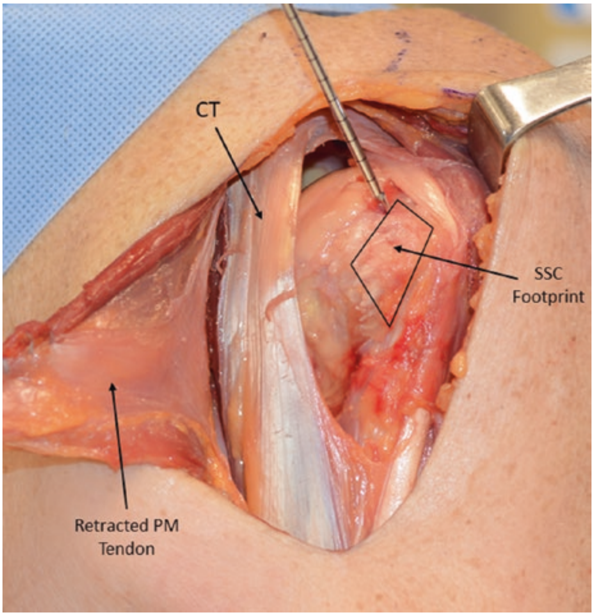

Fig. 8.7 Once the upper 2/3 of the pectoralis major tendon is appropriately released, it is transferred to the original footprint of the subscapularis tendon. CT, conjoint tendon; SSC, subscapularis tendon; PM, pectoralis major tendon

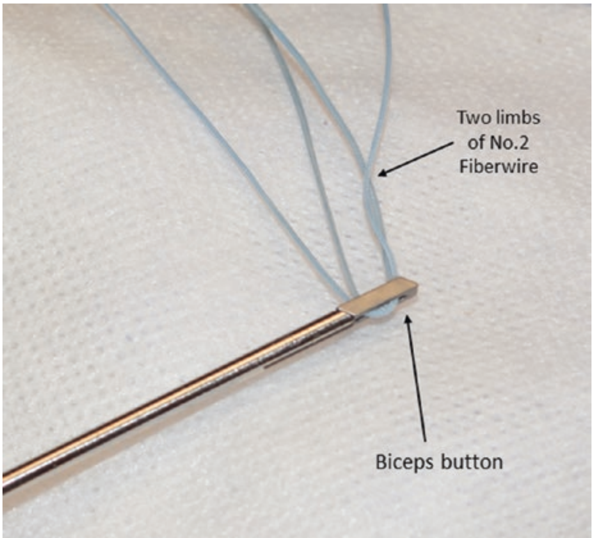

Fig. 8.8 Both limbs of each modified Krakow stitch are inserted into a biceps button in opposite directions

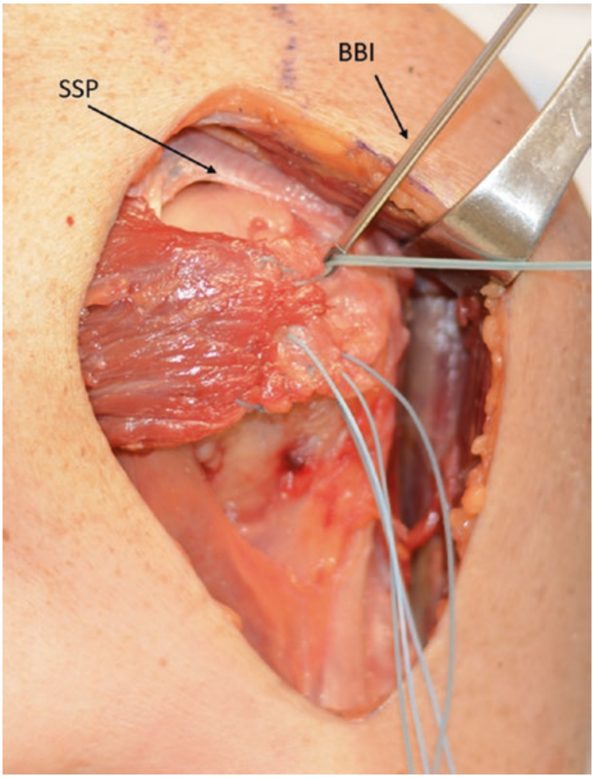

Fig. 8.9 Subsequently, the transferred tendon is fixed to the bone using three biceps buttons. To facilitate inserting, a button inserter can be used. SSP, supraspinatus tendon; BBI, biceps button inserter

Tendon Fixation

A motorized burr or shaver is used to create a bleeding surface on the lesser tuberosity footprint laterally just adjacent to the bicipital groove. The transferred tendon is then fixed using three biceps buttons (Fig. 8.10). Therefore, each button is placed in the corresponding drill hole and flipped until it locks underneath the cortical bone. The two limbs of the fiberwire are then transfixed through the pectoralis major tendon and finally fastened with knots for further compression.

As a rule, the transfer should have tension in neutral position but still allow 30° of passive external rotation. The interval between the anterior part of the supraspinatus and the upper border of the transferred tendon is afterward closed with two or three stitches laterally in the proximity of the greater tuberosity in order to increase stability. This is akin to the closure of the rotator interval when the subscapularis is present. A dynamic evaluation is then performed to assess the stability of the shoulder. Finally, the wound is irrigated, and subcutaneous tissue and skin are closed in a routine layered fashion.

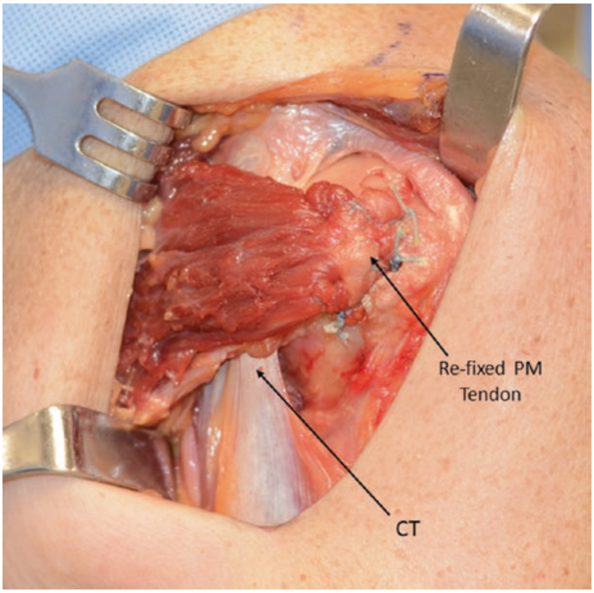

Fig. 8.10 Each button is placed in the corresponding drill hole and flipped until it locks underneath the cortical bone. The two limbs of the fiberwire are then transfixed through the pectoralis major tendon and finally fastened with knots for further compression

Pearls and Pitfalls

Surgical step	Pitfalls	Pearls
Deltopectoral approach	Difficult visualization and identification of the lower border of the pectoralis major	Extended deltopectoral approach
Axillary nerve dissection	Adhesions around the subscapularis can make the nerve identification difficult	Careful subcoracoid release and slight forward flexion of the arm can be helpful to find the nerve
Pectoralis major tendon and muscle release	Medial pectoral nerve and lateral thoracic artery at risk	Limited dissection to 10 cm medial to the tendon insertion
Pectoralis major tendon fixation	Soft bone	Anchors or transosseous fixation can be used
	Too tight or loose fixation	The transferred tendon should be tight in neutral position but still allow for 30° of passive external rotation

Postoperative Management

The shoulder is strictly immobilized in a sling with a 30° abduction pillow for 6 weeks, and passive external rotation is limited to 0–15° during this period to protect the tendon insertion. Passive and active motion of the hand, wrist, and elbow begins the day after surgery. Passive shoulder range of motion with pendulum exercises is initiated after 6 weeks. Active range of motion is initiated at 8 weeks postoperatively. Finally, strengthening exercises begin 3 months after surgery. The recovery time expected for this type of procedure is generally longer than a primary rotator cuff repair, and gains are expected up to 1 year after the procedure.

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Anterior Capsule Reconstruction

9

Jonas Pogorzelski, Erik M. Fritz, and Peter J. Millett

Introduction/Background

Chronic "end-stage" anterior shoulder instability due to structural failure of the subscapularis muscle and the anterior capsule is a rare and challenging pathology for surgeons to manage as poor-quality capsular, labral, and rotator cuff tissue often limits effective healing following repairs. If primary repair is not possible due to retraction and poor tissue quality and the patient too young or too active for an implantation of a reverse total shoulder arthroplasty, reconstruction with an allo- or autograft may be the only therapeutic option. In general, the postoperative results showed varying rates of success, most certainly associated with altered biomechanics, high re-tear rates, and possible complications such as nerve injury. Thus, optimal graft choices, techniques for graft placement and fixation, and rehabilitation protocols are still controversial. The authors prefer using a human acellular dermal allograft for an anterior capsule reconstruction (ACR) as this may offer additional benefits such as superior mechanical strength, especially when compared to the smaller and thinner tendon allografts which have been used previously. Moreover, in patient groups with generalized tissue laxity due to genetic collagen disorders, allografts from non-affected donors have the additional benefit of avoiding the pathology inherent with the donor's autograft tissue.

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Operative Principle

Similar to the superior capsule reconstruction, the implantation of an allograft replaces the torn subscapularis tendon's role as the anterior joint stabilizer, thus preventing the humeral head from migrating anteriorly by acting as a static restraint. This surgery alters shoulder biomechanics as the graft acts as a static restraint, thereby centering the humeral head during active movement, preventing anterior escape, and thus leading to improved function and pain relief.

Indication

ACR is indicated in patients with "end-stage" anterior shoulder instability due to a massive irreparable tear of the subscapularis tendon. These patients tend to be young and active, typically under 65 years of age, and with only limited cuff arthropathy, typically Hamada classification grades 1–3. Additionally, an ACR may be used in patients during implantation of a total shoulder arthroplasty when the subscapularis muscle appears to be insufficient or overtensioned, thus preventing the prosthesis from anterior subluxation or dislocation.

Contraindications

ACR should not be performed in patients with significant rotator cuff tear arthropathy (Hamada classification grades 4–6) as a reverse total shoulder arthroplasty might be the preferred type of treatment in these patients. Additionally, significant general medical comorbidities including cardiac disease, pulmonary disease, and active infection are contraindications to any surgery including an ACR.

Technique

Preoperative Preparation

After the induction of general anesthesia and placement of a regional interscalene block, the patient is placed in the beach-chair position. The operative extremity is then situated in a pneumatic arm holder, and the operative shoulder and axilla are prepared and draped using standard sterile techniques.

Diagnostic Arthroscopy

A standard posterior viewing portal and an additional anterior working portal are routinely created. A 5-mm × 7-cm cannula is inserted in the anterior working portal and a probe inserted. After confirmation of an irreparable subscapularis tear, the remaining rotator cuff tissue is debrided to stable margins. An arthroscopic biceps tenotomy is subsequently performed from its origin at the superior labrum as the biceps reflection pulley is typically destroyed. Soft tissue biceps tenodesis is later performed at the end of the case.

Subacromial Decompression and Acromioplasty

Once inspection and preparation of the glenohumeral joint is done, the arthroscope is next introduced into the subacromial space. If indicated, bursectomy, synovectomy, and subacromial spur removal can be performed using a 4.5 mm shaver and a 3.75 mm suction radiofrequency cautery device. An all-arthroscopic technique can be performed but has the inevitable difficulty of the placement of the infero-medial anchors. In most cases, the authors prefer an open approach.

Open Approach

To start the reconstruction of the anterior capsule, a standard deltopectoral incision of approximately 10 cm is made (Fig. 9.1). After careful dissection of the subcutaneous tissue down to the fascia in the deltopectoral groove, the cephalic vein is exposed and retracted laterally. Afterwards, the conjoint tendon is identified, and care is taken to dissect it laterally. In general, the conjoint tendon should always be retracted medially to avoid excessive tension on the brachial nerves and vessels. Moreover, this exposes the anterior shoulder joint and reveals the irreparable subscapularis tear that was already confirmed arthroscopically.

In order to maximize exposure, several retractors are placed. This includes a retractor deep to the deltoid to retract it superiorly and laterally, a retractor to retract the conjoint tendon medially, and a Fukuda retractor to retract the humeral head posteriorly (Fig. 9.2a).

Fig. 9.1 A standard deltopectoral incision of approximately 10 cm is made in a right shoulder prior to anterior capsule reconstruction

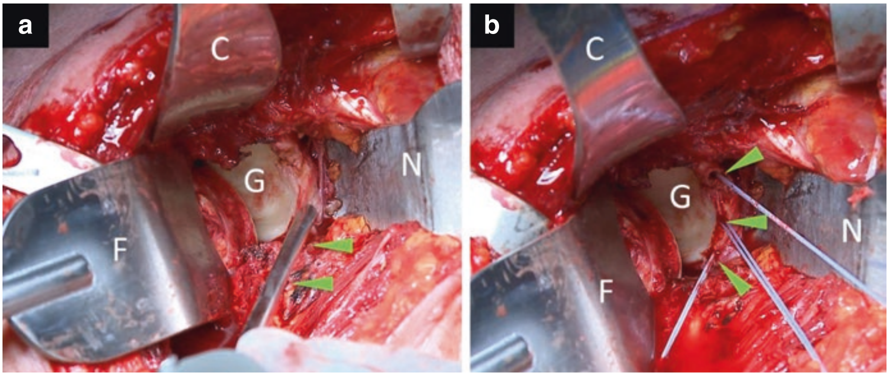

Fig. 9.2 Anterior view of a right shoulder following standard deltopectoral approach; a Fukuda retractor (F) pulls the humeral head posteriorly, while a cobra retractor (C) is used to lever the glenoid (G) into view. (**a**) The anterior glenoid is prepared with a motorized rasp (arrows) to enhance graft-to-bone healing. (**b**) Three preloaded suture anchors are inserted into the anterior glenoid rim at the 1, 3, and 5 o'clock positions

Next, extensive debridement of the remaining labral and capsular tissue is performed at the anterior glenoid rim to create a bleeding bed for optimal postoperative healing of the allograft tissue. For the same purpose, the bony anterior glenoid neck is prepared with a motorized rasp. Finally, three single-loaded 3.0-mm suture anchors are inserted into the anterior glenoid rim at approximately 1 o'clock, 3 o'clock, and 5 o'clock position (right shoulder) (Fig. 9.2b).

At a back table, a 3.5-mm-thick human acellular dermal patch is then incised along its long edge, thereby reducing the graft width according to previously performed measurements of the size of the defect. In contrast to the width, the length of graft is not reduced until it is fixed on the glenoid and lesser tuberosity. The patch is then prepared by marking several parallel lines perpendicular to the length of the graph for later reference in order to ensure that the final graft shape is rectangular.

At this point, the two suture limbs from the 3 o'clock glenoid suture anchor are passed in a mattress configuration through the midpoint of medial part of the graft using any type of suture passer (Fig. 9.3a). Care must be taken to leave approximately 10 mm of space toward the medial margin of the graft to prevent the sutures from cutting through the graft. Subsequently, one limb from each of the 1 o'clock and 5 o'clock anchor is then passed through the superior and inferior edges of the graft, respectively.

The graft is then shuttled down to the glenoid in a "flying carpet" technique (Fig. 9.3b). More precisely, the middle suture limbs are tensioned and tied down with the help of an arthroscopic knot pusher. The additional superior and inferior limbs that were not passed through the graft are passed through the adjacent tissue and tied to their counterpart limb. This prevents "dog-ear" formation on the infero-medial and supero-medial corners. To finish the glenoid-sided fixation of the graft, the remaining excess suture is cut with a suture cutter and discarded.

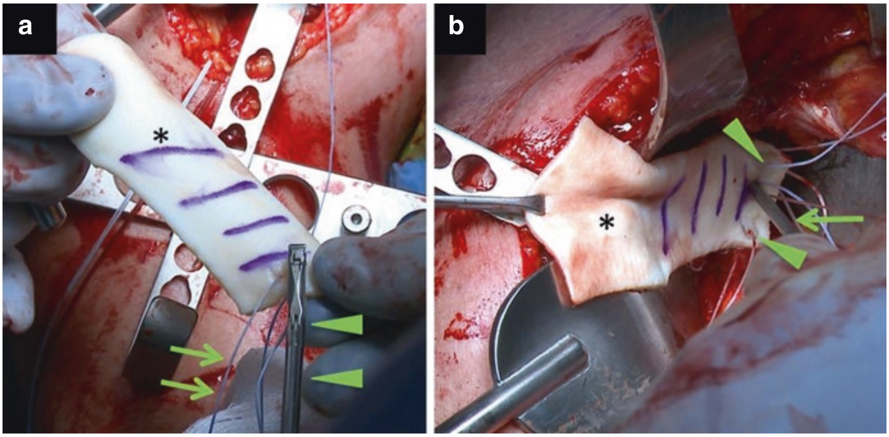

Fig. 9.3 Anterior view of a right shoulder following standard deltopectoral approach demonstrating medial-sided graft preparation and insertion. (**a**) The first suture limb (arrows) from the middle glenoid suture anchor is passed through the superior side of the midpoint of medial edge of the graft using a suture passer (arrowheads); following this step the second limb is passed through the inferior side of the midpoint (not pictured). (**b**) After one limb from each of the inferior and superior suture anchors have been passed through the respective inferior and superior aspects of the medial edge of the graft (arrowheads), the graft is shuttled down to the glenoid with an arthroscopic knot pusher (arrow). *, graft

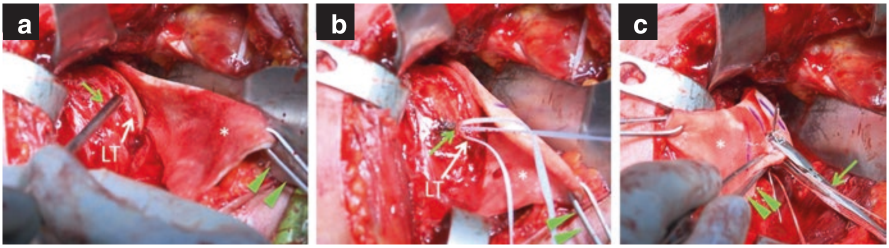

Fig. 9.4 Anterior view of a right shoulder following standard deltopectoral approach and medial-sided graft fixation; this figure demonstrates lateral-sided graft preparation and insertion with the graft being manipulated using an arthroscopic grasper (arrowheads). (**a**) The lesser tuberosity (LT) is prepared with a motorized rasp (arrow). (**b**) Following creation of a bone socket using an arthroscopic punch (not visualized), the infero-medial vented knotless preloaded suture anchor (arrow) is inserted approximately 1–2 mm lateral to the articular margin. (**c**) With an arthroscopic grasper (arrowheads) and suture passer (arrow), each limb of the suture tape and one strand of FiberWire suture is passed through the inferior aspect of the graft; the distance along the length of the graft is determined by the size of the defect and the appropriate level of tension. *LT*, lesser tuberosity; *arrowheads*, arthroscopic grasper; *, graft

Similar to the anterior glenoid rim, the lesser tuberosity is then prepared with a motorized rasp to expose a bleeding surface to optimize healing of the graft laterally (Fig. 9.4a). Typically, a knotless cross-linked double-row repair with four suture anchors is performed. As the subscapularis footprint resembles a trapezoidal shape,

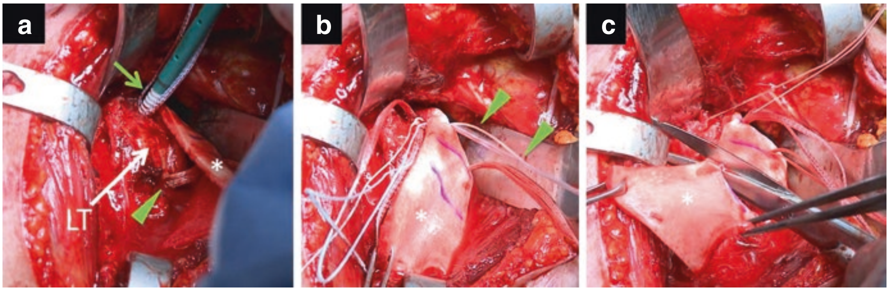

Fig. 9.5 Anterior view of a right shoulder following standard deltopectoral approach demonstrating placement of the medial row of suture anchors for lateral-sided double-row graft (*) fixation. (**a**) The supero-medial vented knotless preloaded suture anchor (arrow) is inserted 10 mm superior to the inferior suture anchor (arrowhead). (**b**) Each limb of the suture tape and one strand of suture has been passed through the inferior aspect of the graft using a suture passer (not visualized). (**c**) The graft (*) is cut along its width about 1 cm lateral to the medial row of suture anchors

the supero-medial anchor is placed more medially than the infero-medial anchor, resulting in a skewed double-row repair to fully cover the footprint. An arthroscopic punch is used to create a bone socket to accommodate the infero-medial anchor approximately 1–2 mm lateral to the bone/cartilage margin. A vented 4.75-mm suture anchor loaded with suture tape and additional suture is subsequently placed in this infero-medial socket (Fig. 9.4b). Each limb of the aforementioned suture tape and one strand of the suture is passed through the inferior aspect of the graft, at a distance along the length of the graft that is determined by the size of the defect (Fig. 9.4c). The other strand of the suture is not passed through the graft but is instead sutured to the surrounding rotator cuff tissue for additional stability. Next, preparation of the supero-medial anchor is performed in an identical fashion, taking care to maintain a 10-mm bone bridge relative to the first medial anchor (Fig. 9.5).

Once the medial row is placed, the graft is then cut along its length approximately 10 mm lateral to the medial row (Fig. 9.5). Next, two suture loops are passed through the infero-lateral and superolateral corners of the graft which will later be used to prevent the graft from getting dog-ear malformation (Fig. 9.6a). An arthroscopic punch is then used to prepare the infero-lateral bone socket approximately 15 mm lateral to the corresponding medial anchor. Limbs of suture tape from the two different medial anchors are crossed and then loaded with one suture from the lateral corners of the graft into the first lateral row anchor. All suture tapes and sutures are pulled to achieve adequate tension, thus securing the allograft patch laterally and completely covering the lesser tuberosity footprint (Fig. 9.6b). After cutting the remaining suture tails, this method is then repeated for the superolateral anchor to complete the lateral fixation (Fig. 9.6c).

To finish the construct, two margin convergence sutures are then placed at the lateral part of the superior aspect of the graft into the leading edge of the supraspinatus tendon that can be identified in the recess of the glenohumeral joint (Fig. 9.7a). Care is taken to leave the rotator interval open. A margin convergence suture can

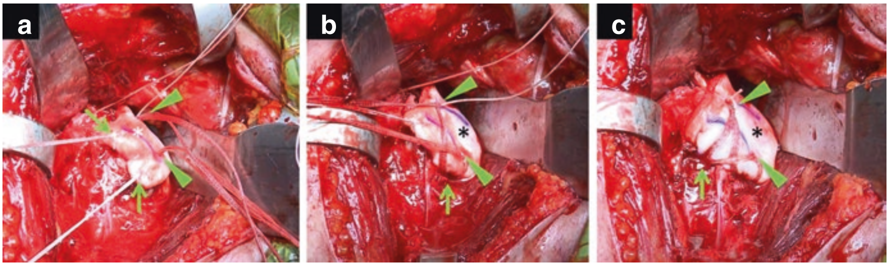

Fig. 9.6 Anterior view of a right shoulder following standard deltopectoral approach and medial row anchor placement (arrowheads) for lateral-sided double-row graft (*) fixation; this figure demonstrates placement of the lateral row of suture anchors. (**a**) Two sutures (arrows) are passed through the inferolateral and superolateral corners of the graft using a suture passer and handtied using a simple knot. (**b**) Following placement of the infero-lateral bone socket 15 mm lateral to the corresponding medial row anchor, limbs of suture tape from the two medial row anchors are crossed then loaded into the first lateral row anchor and inserted into the bone socket (arrow). (**c**) The process is repeated for the superolateral anchor (arrow), and the suture tails are cut completing the suturetape construct

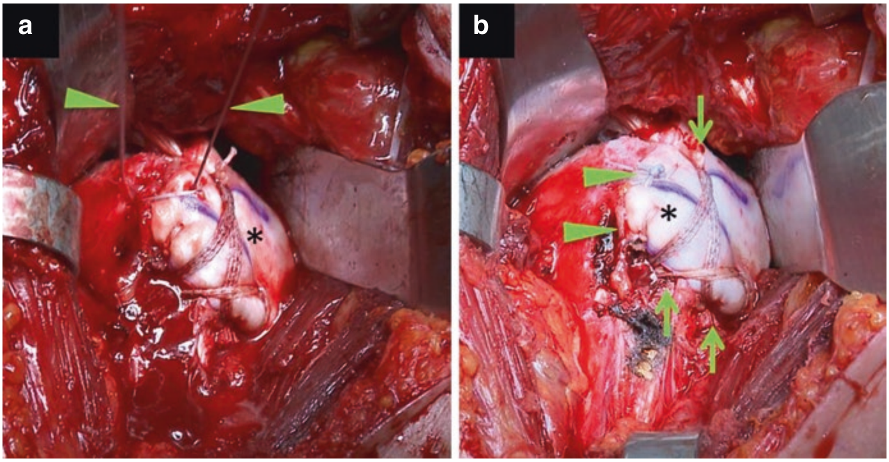

Fig. 9.7 Anterior view of a right shoulder following standard deltopectoral approach and completion of medial and lateral fixation of the anterior graft (*). (**a**) A margin convergence suture (arrowheads) is placed at the supero-lateral part of the graft into the leading edge of the supraspinatus tendon; care is taken to leave the rotator interval open. (**b**) Visualization of the final anterior capsule reconstruction; note the suturetape construct (arrows) and margin convergence sutures (arrowheads)

also be placed along the inferior aspect of the graft to secure it into native cuff tissue for additional stabilization.

All suture tails are cut and the wound is thoroughly irrigated (Fig. 9.7b). Before wound closure, a complete dynamic evaluation is performed with particular

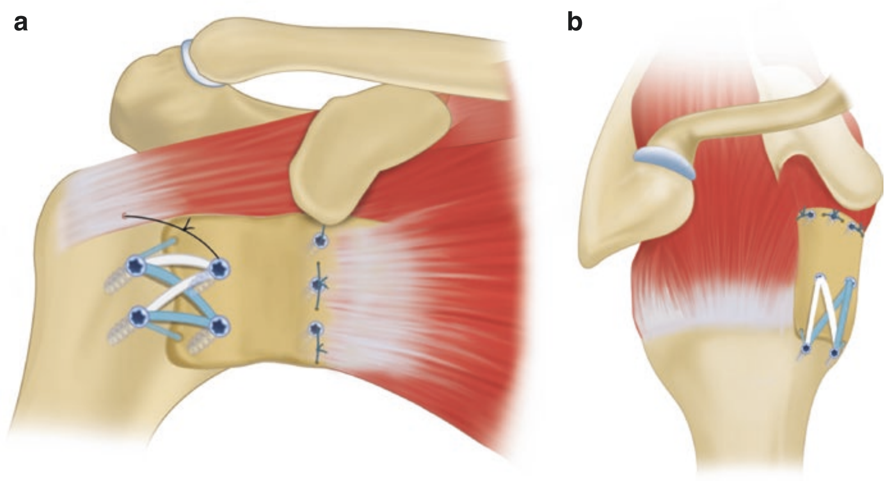

Fig. 9.8 Illustration of a right shoulder demonstrating the final anterior capsule reconstruction construct from an anterior (**a**) and superior (**b**) view. The medial row is fixed to the anterior glenoid with three suture anchors, and the lateral end is fixed to the lesser tuberosity with a knotless double-row construct

emphasis on testing stability in the abducted and externally rotated position to ensure adequate stability and security of the repair (Fig. 9.8).

Pearls and Pitfalls

Surgical steps	Pitfalls	Pearls
Diagnostic arthroscopy	Missing concomitant lesions.	Performing a thorough and standardized examination allows for identification of concomitant lesions.
Medial-row anchor insertions	Dog-ear formation.	The surgeon should start with the middle anchor and fix the graft on the inferior and superior edges with suture loops.
		This technique secures the graft along the anterior glenoid rim and surrounding structures. Careful attention to suture management is critical while retrieving and passing the sutures.
Preparation of patch according to defect size	Incorrect size measurement, resulting in a graft that is too large or too small.	Use of a template or an arthroscopic ruler beforehand.
Medial-row anchor insertions	Dog-ear formation.	The supero-medial anchor should be placed more medially than the infero-medial anchor due to the trapezoidal shape of the SSC footprint.

Surgical steps	Pitfalls	Pearls
Lateral-row anchor insertions and fixation	Insufficient overview.	A radiofrequency device can be used to mark the location for the anchors to be inserted.
	Soft bone.	Assess bone quality with a punch. If the bone is soft, a 5.5-mm suture anchor should be used instead of a 4.75 mm suture anchor
Postoperative rehabilitation	Postoperative stiffness.	Early passive range of motion for 4 weeks. Progression to full passive motion and start of active and active-assisted motion at 6 weeks postoperatively.

Postoperative Management

Postoperatively, patients must follow a strict rehabilitation protocol beginning with shoulder immobilization in a sling with external rotation limited to 30° for 6 weeks. If a biceps tenodesis is also performed, resisted elbow flexion should be restricted for 6 weeks. Wrist and hand exercises are permitted during this time. Pendulum exercises are initiated after 6 weeks. Active range of motion is started at 8–10 weeks. Return to daily activities is expected after 6 months when full range of motion and strength have been achieved. Patients are counseled that there is the potential for some loss of external rotation and forward flexion; however, the goal is to obtain a stable shoulder with at least 45° of external rotation and 140° of forward flexion.

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Part III

Glenohumeral Instability

10 Anterior Instability Without Bone Loss: Bankart Repair

Burak Altintas, Jonathan A. Godin, and Peter J. Millett

Introduction/Background

Anterior shoulder dislocation involves rupture of the inferior glenohumeral ligament (IGHL), giving rise to different types of capsuloligamentous injuries, including Bankart lesions, humeral avulsion of the glenohumeral ligament (HAGL) injuries, and anterior labroligamentous periosteal sleeve avulsion (ALPSA) lesions. A Bankart lesion represents an avulsion of the anterior band of the IGHL from the glenoid. Arthroscopic Bankart repair with knotless suture anchors is an elegant, minimally invasive technique for the treatment of anterior glenohumeral instability without significant bone loss. Advantages of this technique over open procedures include minimal invasiveness, superior visualization, treatment of concomitant pathologies, and more precise restoration of the native anatomy.

Operative Principle

The superomedial re-fixation of the torn IGHL complex and labrum restores the anatomy and tightens the axillary pouch, thus preventing the humeral head from migrating anteroinferiorly (Fig. 10.1).

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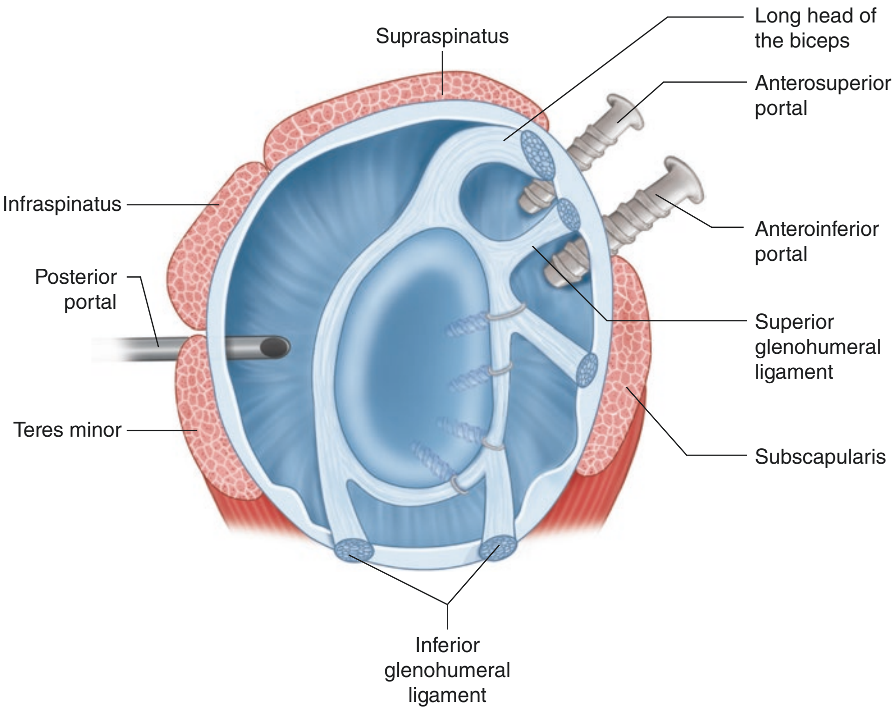

Fig. 10.1 Illustration of a right shoulder from a sagittal view demonstrating the repaired labrum, shifted capsule, and IGHL complex with three knotless suture anchors

Indications

Arthroscopic Bankart repair is indicated in patients with capsulolabral disruption and anterior instability with minimal or no glenoid bone loss. Moreover, it is the preferred primary surgical treatment in young and active patients after a traumatic anterior shoulder dislocation.

Contraindications

Arthroscopic Bankart repair should not be performed on patients with significant (>25%) glenoid bone loss. Patients with generalized ligamentous laxity demonstrate a relative contraindication due to poor tissue quality.

Technique

Preoperative Preparation

After the induction of general anesthesia and placement of a regional interscalene block, the patient is placed in the beach-chair position. The operative extremity is then carefully situated in a pneumatic arm holder, and the operative shoulder and axilla are prepared and draped using standard sterile techniques.

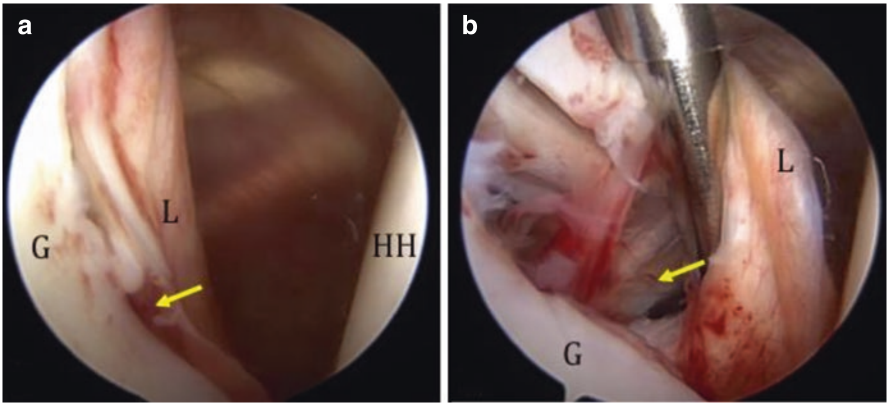

Fig. 10.2 (**a**) Arthroscopic view of a right shoulder through the posterior portal demonstrating an anteroinferior capsulolabral rupture (arrow). (**b**) Assessment with the probe from the anterosuperior portal between the labrum and anterior glenoid. G, glenoid; HH, humeral head; L, labrum

Diagnostic Arthroscopy

Standard posterior and anterosuperior portals are created. A 5 mm cannula is inserted in the anterosuperior portal located at the superior border of the rotator interval, directly inferior to the biceps tendon. The Bankart lesion is assessed with a probe (Fig. 10.2a). It is important to place the anteroinferior portal close to the superior subscapularis border to ensure enough spacing between the anterosuperior and anteroinferior portals. Moreover, be sure the anteroinferior glenoid rim can be reached through the anteroinferior portal. Next, an 8.25 mm cannula is inserted in the anteroinferior portal for easier suture management. During the diagnostic arthroscopy, careful examination of the superior labrum for a possible superior labrum anterior to posterior (SLAP) tear and the long head of the biceps tendon for possible pulley pathology is necessary. Additionally, the axillary recess should be examined for a HAGL lesion and the posterosuperior humeral head for a Hill-Sachs defect. Following diagnostic arthroscopy, a 70° arthroscope is introduced through the posterior portal for better visualization of the anteroinferior labrum. After confirmation of an anterior capsulolabral tear (Fig. 10.2b), an elevator is used to mobilize the labrum. Thereafter, a bleeding bed along the anteroinferior glenoid is created with a shaver to enhance tissue healing to the bone (Fig. 10.3). The bleeding glenoid repair site may be furthered prepared using a combination of bur, rasps, and curettes.

ALPSA Lesions

The anteroinferior labral tissue may roll up like a sleeve and become displaced inferomedially resulting in an ALPSA lesion. The treatment principle is the same as that for Bankart tears. When an ALPSA lesion is present, extra attention should be paid to adequate mobilization of the labral tissue, as it may have extensive scarring on the inferomedial glenoid.

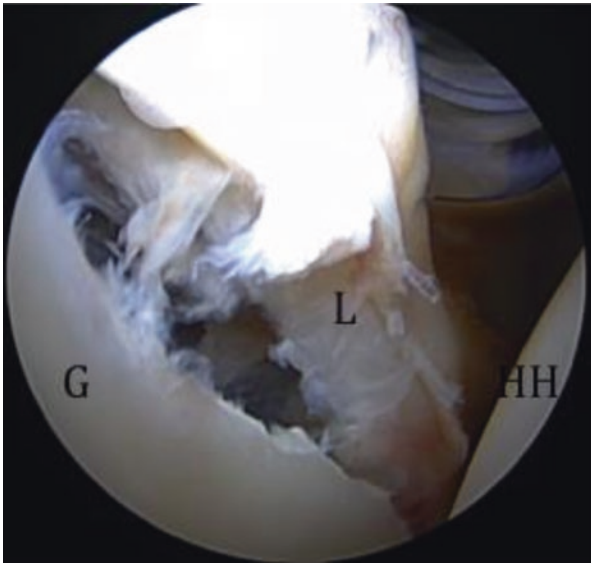

Fig. 10.3 Arthroscopic view of a right shoulder through the posterior portal showing the entire lesion after mobilization. G, glenoid; HH, humeral head; L, labrum

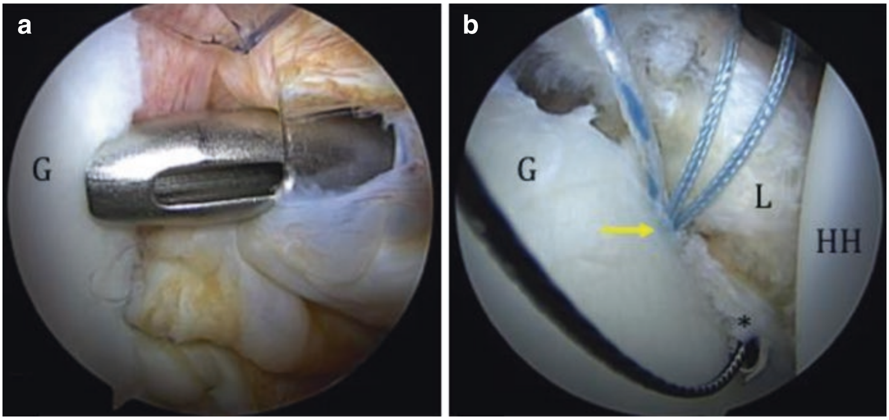

Fig. 10.4 (**a**) With the arthroscope in the posterior portal of the right shoulder, a suture anchor (arrow) is inserted into the anteroinferior glenoid through the anteroinferior portal. (**b**) A curved suture passer is passed through the capsulolabral tissue inferior to the anchor (asterisk). (G, glenoid; HH, humeral head; L, labrum)

Placement of the 5:30 O'clock Anchor

The drill sleeve is passed through the anteroinferior cannula and placed on the anteroinferior glenoid rim. After drilling, the first anchor is placed at the 5:30 o'clock position on the glenoid by gentle impaction (Fig. 10.4a). Next, the repair suture (white-blue) is retrieved through the anterosuperior portal with a suture grasper. A curved suture passer (left curve for right shoulder) is introduced through the anteroinferior cannula and passed through the capsulolabral tissue

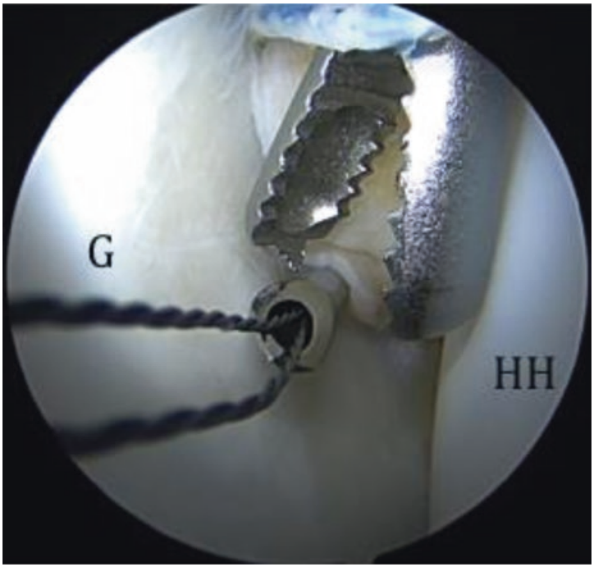

Fig. 10.5 While viewing through the posterior portal of a right shoulder, the nitinol wire loop is introduced into the joint and retrieved through the anterosuperior portal using a grasper. (G, glenoid; HH, humeral head)

inferior to the anchor (Fig. 10.4b). During this, the capsulolabral tissue can be reduced to the glenoid rim with the help of a grasper introduced through the anterosuperior portal. A nitinol wire loop is then introduced into the joint and retrieved through the anterosuperior portal using a grasper (Fig. 10.5).

After the repair suture is placed through the wire loop, the wire loop is shuttled in a retrograde fashion through the anteroinferior portal. Then, the repair suture is passed through the loop of the shuttling suture, and the free end of the blue shuttling suture is pulled to shuttle the repair suture back into the anchor. It is advised to grab the capsulolabral tissue superior to the knot with a grasper to position the anteroinferior labrum with the desired tension (Fig. 10.6). Then, the knot is tightened to the desired tension and cut flush with the glenoid surface with an arthroscopic suture cutter. This enables shifting the IGHL complex and labrum superomedially to tighten the axillary pouch.

Placement of Additional Anchors

A minimum of three anchors should be used for adequate Bankart repair. These are placed inferiorly to superiorly in the same fashion (Fig. 10.7).

Treatment of Glenolabral Articular Disruption (GLAD) Lesions

Anteroinferior labral tears may be associated with GLAD lesions. In these cases, the articular defect of the anterior glenoid is treated with chondroplasty and microfracture prior to capsulolabral re-fixation (Fig. 10.8).

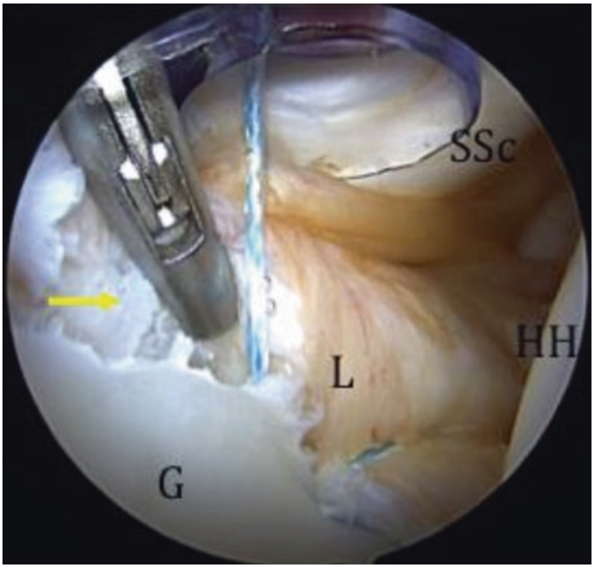

Fig. 10.6 While viewing through the posterior portal of a right shoulder, a grasper (arrow) is introduced from the anterosuperior portal to grab the capsulolabral tissue superior to the anchor to position the anteroinferior labrum with the desired tension. (G, glenoid; HH, humeral head; L, labrum; SSc, Subscapularis)

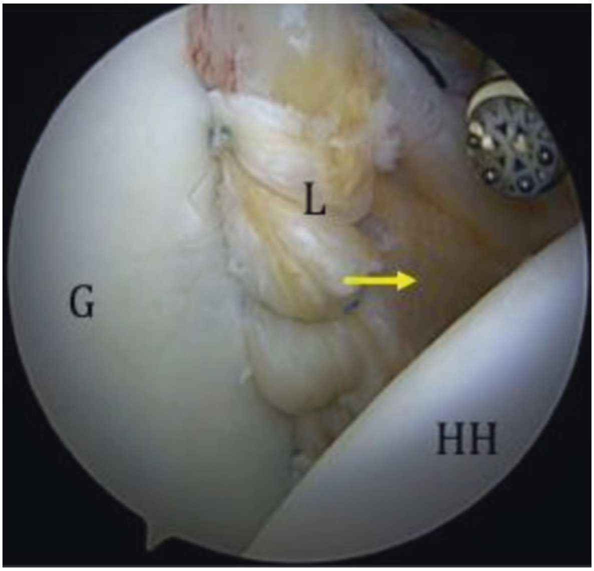

Fig. 10.7 View of a right shoulder after complete arthroscopic Bankart repair. The anteroinferior capsulolabral tissue is shifted superomedially (arrow). (G, glenoid; HH, humeral head; L, labrum)

Postoperative Management

Following surgery, patients are immobilized in a sling for 6 weeks. The rehabilitation goals during this time include protecting the surgical repair, minimizing pain and swelling, as well as beginning early passive shoulder motion. Attention should

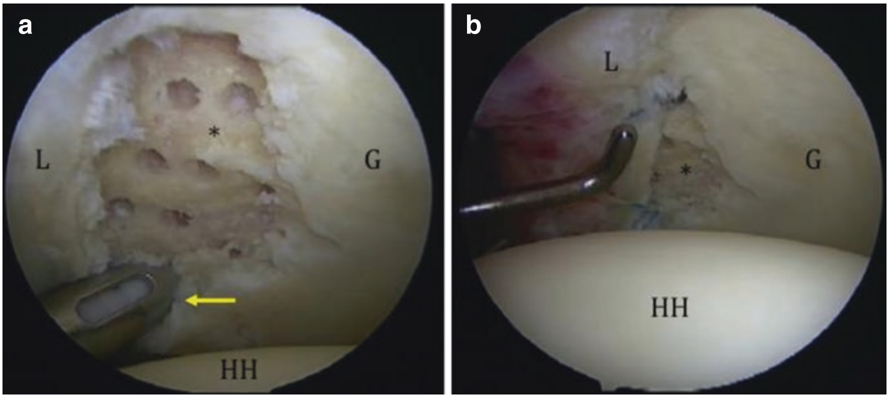

Fig. 10.8 View of a left shoulder with a GLAD lesion. (**a**) A suture anchor (arrow) is placed at the 6:30 o'clock position after microfracture of the anterior glenoid articular defect (asterisk). (**b**) The anteroinferior capsulolabral re-fixation is performed as described above (arrow). (G, glenoid; HH, humeral head; L, labrum)

be paid to maintaining mobility of accessory joints (fingers, wrist, elbow). While gradual passive range of motion is encouraged, the external rotation is limited to 30°. After 6 weeks, the sling is removed, and active range of motion of the glenohumeral joint without restrictions is started. Muscular strengthening is also introduced at 6 weeks postoperatively and consists of progressive resisted ROM and initial closed chain exercises. After 4 months, patients are cleared to return to full activities.

Pearls and Pitfalls

Surgical step	Pitfalls	Pearls
Diagnostic arthroscopy	Inability to visualize associated pathologies (ALPSA, HAGL, etc.)	Performing a thorough and standardized examination allows for identification of concomitant lesions
Anchor insertion	Malpositioning of the anchors, with potential damage to the glenoid cartilage	Insertion of the 5:30 o'clock anchor through the anteroinferior portal. If not possible, creation of a trans-subscapular portal to aid anchor placement
Capsulolabral repair	Inadequate tensioning of the capsulolabral tissue	Pulling the tissue superiorly and medially from the anterosuperior portal with a grasper, before securing the knot, helps control the tension of the shift
	Recurrent instability	Using a minimum of three suture anchors
	Malreduction of the capsulolabral tissue to the glenoid	Adequate mobilization and excursion with a grasper before re-fixation

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11 Anterior Instability with Bone Avulsion: Bony Bankart Bridge Procedure

Burak Altintas, Jonathan A. Godin, Erik M. Fritz, and Peter J. Millett

Introduction/Background

Avulsion fractures of the anteroinferior glenoid rim, also known as bony Bankart lesions, are commonly associated with anterior glenohumeral dislocations. Because bone deficiency of the anteroinferior glenoid can contribute to recurrent glenohumeral instability, bony Bankart lesions should be repaired whenever feasible. The Bony Bankart Bridge technique is a reproducible and excellent way of arthroscopically treating these lesions. Advantages of this technique over open procedures include superior visualization, anatomic reduction with fragment compression, and minimal invasiveness.

Operative Principle

Two-point fixation of the bony Bankart lesion enables anatomic reduction and compression without detachment of the labrum and the inferior glenohumeral ligament (IGHL) from the bony fragment. Additional fixation of the capsulolabral tissue inferiorly and superiorly to the bony fragment provides additional stability (Fig. 11.1).

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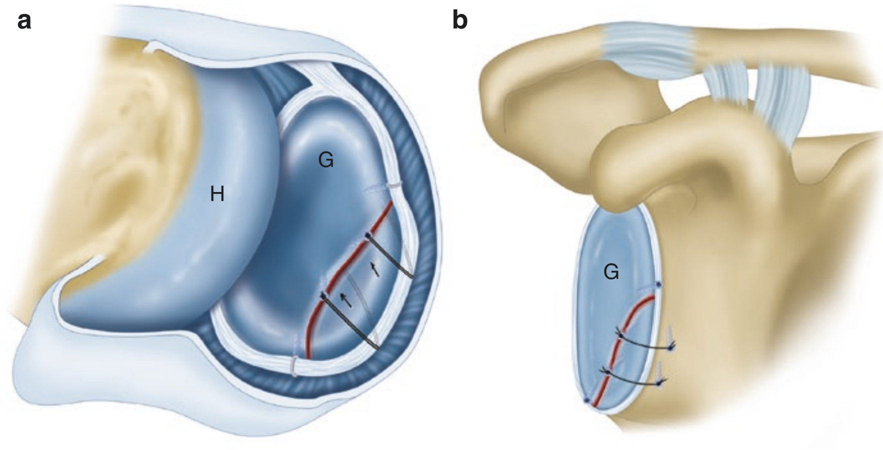

Fig. 11.1 Illustration of a right shoulder demonstrating the Bony Bankart Bridge fixation. (**a**) On the sagittal view, note the sutures passing around the fractured anteroinferior glenoid. (**b**) The anterior view showing the positioning of the anchors medial and lateral to the bony Bankart lesion. (G, glenoid; H, humeral head)

Indications

This technique can be used to treat acute bony Bankart lesions, as well as chronic cases with a mobile fragment possessing sufficient bone stock.

Contraindications

Arthroscopic Bony Bankart Bridge repair should not be performed on patients with fixed and thus irreducible fragments, chronic lesions with small fragments, or bone loss secondary to resorption. Moreover, poor tissue quality due to generalized ligamentous laxity is a relative contraindication.

Technique

Preoperative Preparation

After the induction of general anesthesia and placement of a regional interscalene block, the patient is placed in the beach-chair position. Examination under anesthesia is conducted, noting range of motion, the degree of both anterior and posterior instability, as well as the presence or absence of a sulcus sign. The operative extremity is then situated in a pneumatic arm holder, and the operative shoulder and axilla are prepared and draped using standard sterile techniques.

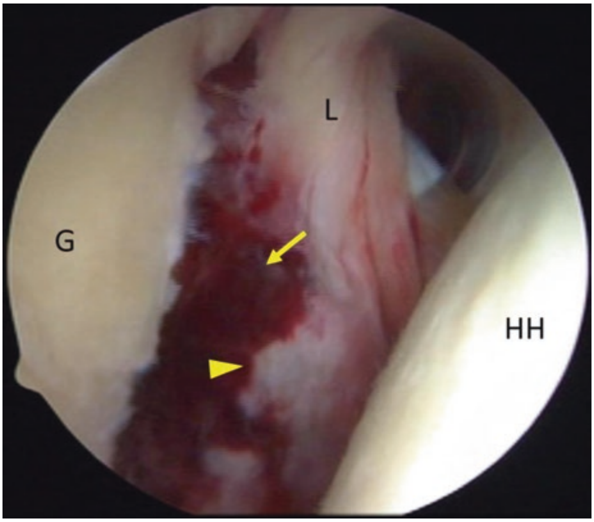

Fig. 11.2 Arthroscopic view of a right shoulder through the posterior portal demonstrating an anteroinferior capsulolabral rupture (arrow). The glenoid bone fragment can also be seen here (arrowhead). (G, glenoid; HH, humeral head; L, labrum)

Diagnostic Arthroscopy

A standard posterior portal is created, and the arthroscope is placed in the joint. Next, an anterosuperior portal is established at the superior border of the rotator interval followed by placement of a 5.0 mm cannula. Subsequently, an accessory anteroinferior portal with an 8.25 mm cannula is placed just superior to the subscapularis tendon. Diagnostic arthroscopy is carried out to assess for any concomitant pathology, and the bony Bankart lesion is assessed with a probe. Thereafter, the 30° arthroscope is switched to a 70° arthroscope through the posterior portal for accurate visualization of the glenoid neck, especially medial to the fracture (Fig. 11.2). Next, the bony fragment, along with the labrum and inferior glenohumeral ligament (IGHL), is mobilized by use of an elevator. The capsulolabral complex is usually attached to the fractured fragment, and caution is necessary to preserve these attachments. The glenoid neck and the posterior surface of the fractured fragment are prepared with a shaver to create bleeding surfaces for optimal bone-to-bone healing (Fig. 11.3).

Placement of the Medial Anchor(s)

The fractured fragment is lifted off the glenoid neck to visualize the medial border of the fracture. The number of medial anchors depends on the size of the fragment. Usually, 1 or 2 anchors are sufficient. In cases where a single medial anchor is placed, it is positioned medial to the fracture site and centrally along the fragment in the sagittal plane. A 70 degree arthroscope is used to facilitate visualization along the glenoid neck. If two anchors are needed, they should be placed at the junction of the superior and middle thirds, as well as the junction of the middle and inferior thirds, of the bony fragment. After drilling through the anteroinferior

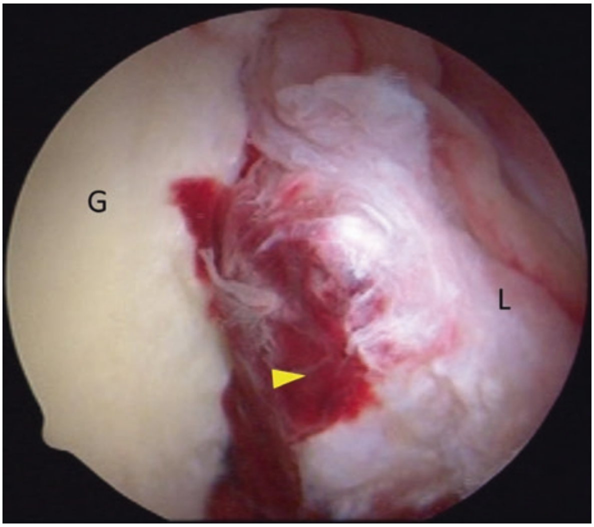

Fig. 11.3 Arthroscopic view of a right shoulder through the posterior portal showing the entire lesion after mobilization. The glenoid bone fragment is clearly visible (arrowhead). (G, glenoid; L, labrum)

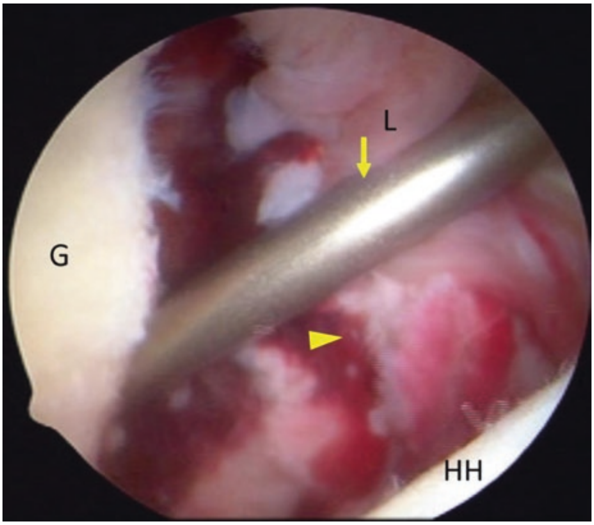

Fig. 11.4 Arthroscopic view of a right shoulder through the posterior portal. Using the anteroinferior portal, a drill (arrow) is used to prepare a hole within the fracture site (bone fragment indicated by arrowhead) for placement of the medial suture anchor for the Bony Bankart Bridge construct. (G, glenoid; HH, humeral head; L, labrum)

cannula with a sleeve to protect the surrounding soft tissue, a 3 mm anchor with high-strength, nonabsorbable suture is placed on the glenoid neck by gentle impaction (Fig. 11.4). Next, after passage of the anchor's sutures through the capsule medial to the fragment, the sutures are gently pulled through the soft tissues with a switching stick to ensure the sutures are not obstructed by any soft tissue bridges. An arthroscopic hook is then used to shuttle the sutures through the anterosuperior portal where they are temporarily placed, leaving the anteroinferior working portal free until the bridging sutures are needed later in the procedure (Fig. 11.5).

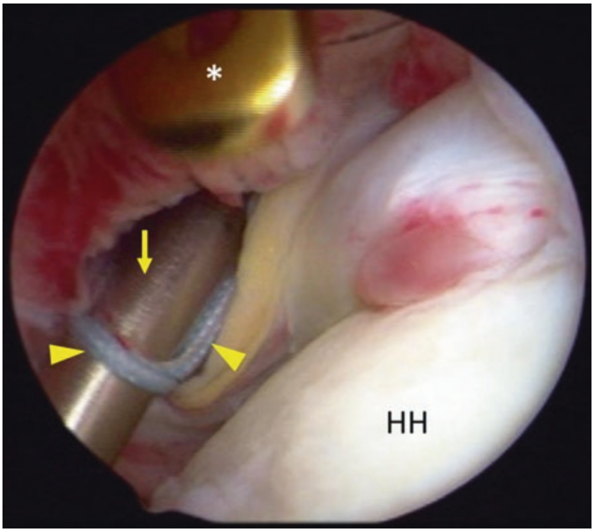

Fig. 11.5 Arthroscopic view of a right shoulder through the posterior portal. Following placement of the medial suture anchor for the Bony Bankart Bridge construct and subsequent passage of the anchor's sutures through the capsule (not visualized), the sutures (arrowheads) are gently pulled through the soft tissues with a switching stick (arrow) to ensure the sutures are not obstructed by any soft tissue bridges. Using an arthroscopic hook (*), the sutures are shuttled through the antero-superior portal where they are temporarily placed, leaving the anteroinferior working portal free until the bridging sutures are needed later in the procedure. (HH, humeral head)

Placement of the Inferior Anchor

A suture anchor is placed inferior to the fracture site to secure the labrum and IGHL complex. This is done in the same fashion as described in the arthroscopic Bankart repair chapter. Briefly, after placing a suture anchor in the 5:30 o'clock position for a right shoulder (Fig. 11.6), the repair suture is passed through the capsulolabral complex and tightened with the help of the shuttling sutures. Reducing the tissue superomedially with a grasper through the anterosuperior portal helps control the size of the shift.

Alternative Percutaneous Placement of Medical Anchor and Suture Passage

Once the surgeon becomes comfortable with the anatomy and the orientation for the anchor placement on the glenoid neck, the medial anchor can be placed percutaneously into the glenoid neck. The drill guide is inserted percutaneously and the anchor is placed blindly in the glenoid neck. After the anchor is secured in the bone, the anchor guide can then be used to pass the suture by manipulating it anterior to the bone fragment and then popping it through the capsule and into the joint. The sutures can then be easily retrieved. In this way, the medial anchor is placed

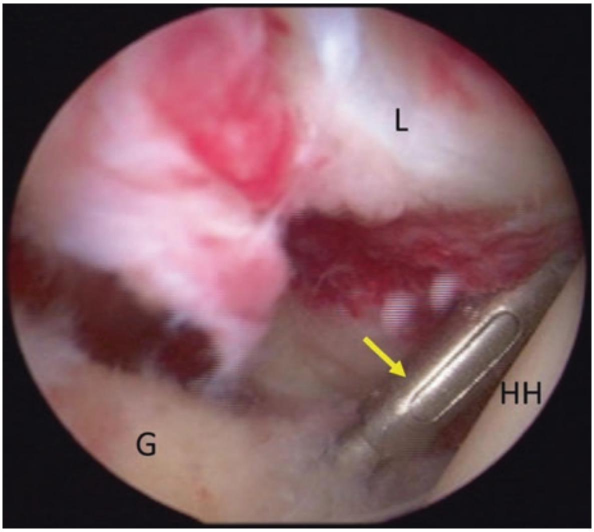

Fig. 11.6 Arthroscopic view of a right shoulder through the posterior portal. Standard Bankart repair suture anchors are placed to approximate the labrum prior to final fixation of the Bony Bankart Bridge construct. Here, the placement of the most anteroinferior suture anchor at 5:30 o'clock position is visualized with the drill inside the drill guide (arrow). (G, glenoid; HH, humeral head; L, labrum)

and the sutures are passed around the bony Bankart fragment in one step. This is presently the senior author's preferred method of passing sutures around the bone fragment.

Fixation of the Fragment

The sutures from the medial anchor are retrieved from the anterosuperior portal and pulled through the anteroinferior portal with a suture grasper (Fig. 11.7). The proper reduction of the fragment and the tension are assessed by pulling the soft tissues to the glenoid rim. The drill hole is placed on the glenoid margin between the lateral edge of the fracture and the glenoid cartilage. Following this, the two free suture limbs from the medial anchor are fed into a 3.5 mm anchor (Fig. 11.8). After adequate tensioning, the anchor is inserted in the drill hole. The sutures are then cut flush with the glenoid surface with an arthroscopic suture cutter. This provides not only anatomic reduction but also sufficient compression of the fragment to the anterior glenoid, thereby providing a proper environment for bone-to-bone healing (Fig. 11.9).

Placement of the Superior Anchor(s)

Additional fixation of the superior capsule, labrum, and middle glenohumeral ligament is performed in the same fashion as previously described for the inferior anchor placement. It is recommended to use at least one anchor superior to the bony Bankart fragment to provide additional stability to the construct (Fig. 11.10).

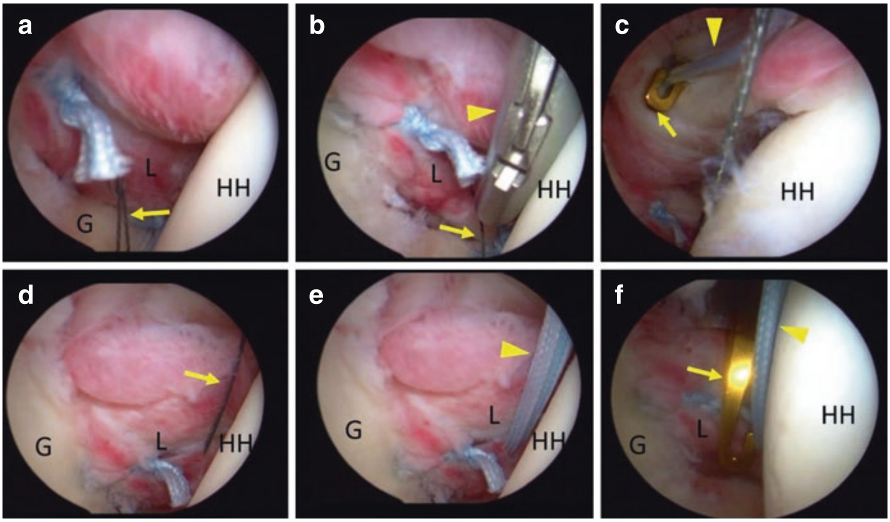

Fig. 11.7 Arthroscopic view of a right shoulder through the posterior portal. Following the placement of standard Bankart repair suture anchors (not visualized), the suture management prior to final placement of the lateral row of the Bony Bankart Bridge construct is visualized in this figure. (**a**) Through the anteroinferior portal, a suture lasso is passed through the labrum (L), and the nitinol wire (arrow) is grasped (**b**) by an arthroscopic grasper (arrowhead) and shuttled out the anterosuperior portal. (**c**) An arthroscopic hook (arrow) is subsequently used to pull the bridging sutures (arrowhead) from the anterosuperior portal out the anteroinferior portal. (**d**) Outside the anteroinferior portal, the bridging sutures are loaded onto the nitinol wire loop (not visualized), and the other end of the nitinol wire (arrow) is pulled out the anterosuperior portal, (**e**) thus shuttling the bridging sutures (arrowhead) through the labrum and out the anterosuperior portal. (**f**) An arthroscopic hook (arrow) is once more used to shuttle the bridging sutures (arrowhead), which are now passed through the labrum, out the anteroinferior portal prior to the placement of the final anchor in the Bony Bankart Bridge construct. (G, glenoid; HH, humeral head; L, Labrum)

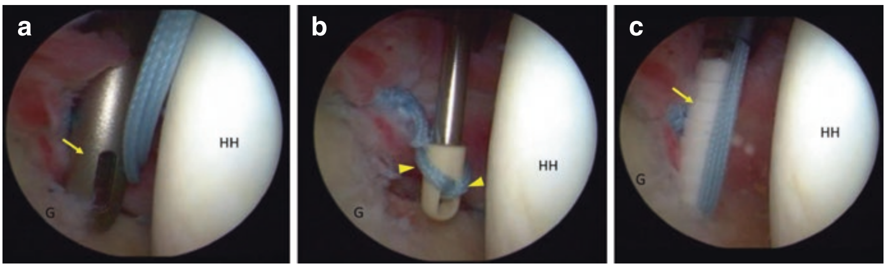

Fig. 11.8 Arthroscopic view of a right shoulder through the posterior portal visualizing placement of the final suture anchor to complete the Bony Bankart Bridge construct. (**a**) Via the anteroinferior portal, a drill guide (arrow) is used to drill the hole for the suture anchor on the glenoid margin between the lateral edge of the fracture and the glenoid cartilage. (**b**) The two free bridging suture limbs from the medial anchor (arrowheads) have been loaded onto (**c**) a 3.5 mm anchor (arrow) which is inserted into the drill hole. (G, glenoid; HH, humeral head)

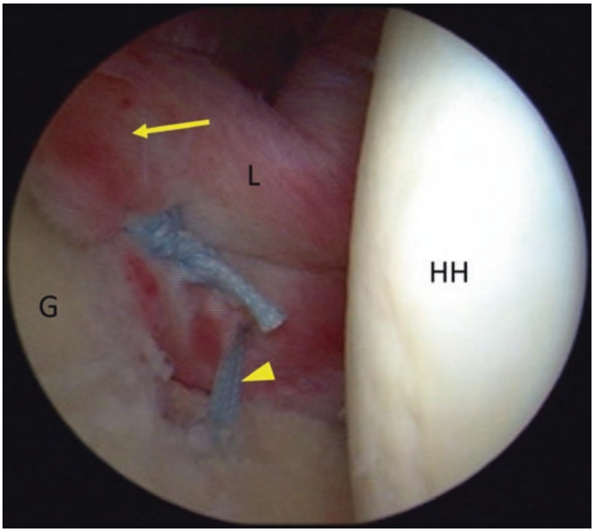

Fig. 11.9 View of a right shoulder after complete arthroscopic Bony Bankart Bridge repair with the bridging sutures marked with an arrowhead. The anteroinferior capsulolabral tissue is shifted superomedially (arrow). (G, glenoid; HH, humeral head; L, labrum)

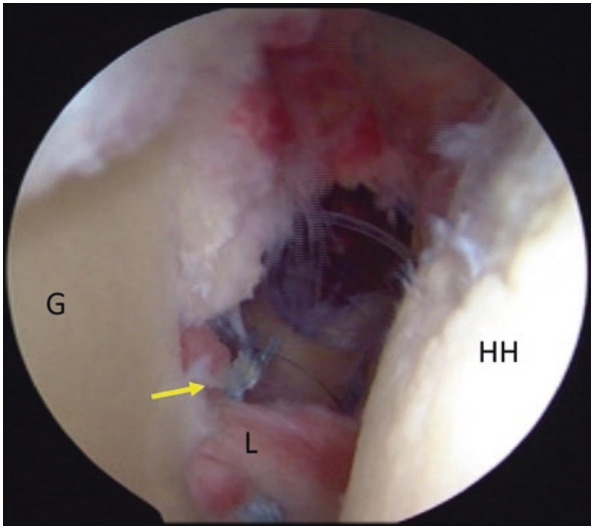

Fig. 11.10 View of the right shoulder through the posterior portal demonstrating placement of one anchor (arrow) superior to the bony Bankart fragment which provides additional stability to the construct. (G, glenoid; HH, humeral head; L, labrum)

Pearls and Pitfalls

Surgical step	Pitfalls	Pearls
Portal placement	Inability to visualize the bony Bankart lesion	Place a high anterosuperior and/or an accessory anteroinferior portal(s) Use a 70° arthroscope
Anchor placement	Malpositioning of the medial anchors	Lifting the bony fracture piece off the glenoid neck with an elevator from the anterosuperior portal helps visualize the medial border of the donor site

Surgical step	Pitfalls	Pearls
Fixation of the bony Bankart fragment	Malreduction	Mobilize the bony Bankart and entire IGHL as a sleeve of continuous tissue
	Inadequate tensioning	Pull the sutures from the medial anchor through the anteroinferior cannula and evaluate the optimal lateral anchor position with desired tension

Postoperative Management

Postoperatively, the shoulder is immobilized in a sling for 4 weeks. Early passive range of motion exercises with supervised active motion, limiting external rotation to 30°, is encouraged in this phase. Beginning in the fifth postoperative week, the patient is advanced to full active range of motion with a strengthening program beginning 6–8 weeks postoperatively. At 3–4 months postoperatively, the patient is cleared to return to non-contact sports. Full return to contact or throwing sports is delayed until an average of 6 months postoperatively if complete radiological healing is present.

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12 Anterior Instability: Arthroscopic HAGL Repair

Burak Altintas, Jonathan A. Godin, Erik M. Fritz, and Peter J. Millett

Introduction/Background

Humeral avulsion of glenohumeral ligaments (HAGL) is much less common than labral injuries following anterior shoulder dislocation, but this pathology may contribute to recurrent instability. Therefore, surgical repair of these lesions is generally recommended. Due to the inferolateral attachment of the inferior glenohumeral ligament (IGHL) on the humeral neck, the arthroscopic treatment of HAGL lesions is technically challenging and demanding. Advantages of this technique over other arthroscopic and open procedures include better visualization and anatomic fixation of the avulsed IGHL with minimal invasiveness.

Operative Principle

The anatomical repair of the IGHL complex to the humeral insertion site tightens the axillary pouch, thus adding additional stability.

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Indications

Arthroscopic HAGL repair is indicated in patients with recurrent instability after failed conservative treatment and in patients with high activity levels. In addition, a HAGL lesion as a concomitant injury during arthroscopic treatment of anterior instability should be treated to minimize the risk of failure.

Contraindications

HAGL repair should not be performed on patients with fixed and thus irreducible fragments or bone loss secondary to resorption. Moreover, poor tissue quality due to generalized ligamentous laxity is a relative contraindication.

Technique

Preoperative Preparation

After the induction of general anesthesia and placement of a regional interscalene block, the patient is placed in the beach chair position. An exam of the shoulder is performed to assess the degree of humeral head translation. The operative extremity is then situated in a pneumatic arm holder with 20° of forward flexion and 50° of abduction to modify tension on the inferior capsule for optimal reattachment of the IGHL. The operative shoulder and axilla are prepared and draped using standard sterile techniques.

Diagnostic Arthroscopy

Standard posterior and anterosuperior portals are created. The HAGL lesion (Fig. 12.1) is assessed with a probe. It is essential to create an accessory posteroinferior portal at 7 o'clock position under direct visualization using a spinal needle and switching stick (Fig. 12.2a). The incision for this portal is usually located about 2–3 cm inferior to the standard posterior viewing portal. Next, an 8.25 mm cannula that has deployable wings to secure it in the joint is inserted in the posteroinferior portal for easier suture management (Fig. 12.2b). Because of the proximity of the axillary nerve, this cannula is inserted carefully over a switching stick and dilators.

HAGL Repair

After confirmation of the HAGL lesion, the humeral neck is debrided with a shaver introduced from the posteroinferior portal to create a bleeding bed for anchor

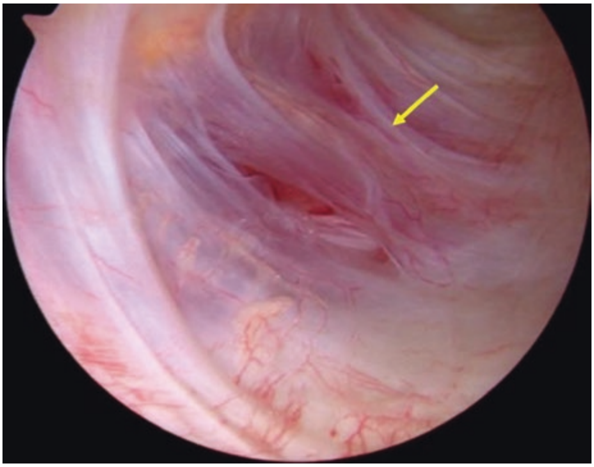

Fig. 12.1 Arthroscopic view of a left shoulder through the posterior portal demonstrating an anteroinferior capsulolabral rupture (arrow)

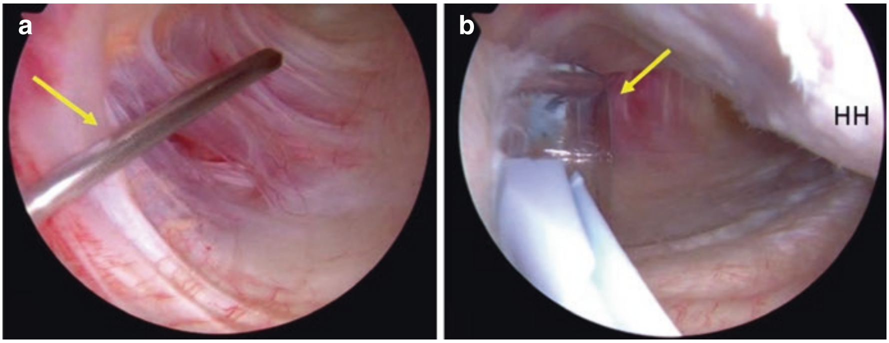

Fig. 12.2 Arthroscopic view of a left shoulder through the posterior viewing portal visualizing the inferior capsular recess, HAGL lesion, and placement of the posteroinferior portal. (**a**) A spinal needle (arrow) is used to directly visualize the location of the portal. (**b**) Following the use of a switching stick (not visualized) for portal placement, an 8.25 mm cannula (arrow) is inserted to facilitate anchor placement and suture management. HH = humeral head

insertion. The capsulolabral tissue is reduced with an arthroscopic grasper to aid in the assessment of the damage and repair planning (Fig. 12.3).

Depending on the size of the tear, one or two suture anchors may be placed in the humeral neck. In the case of two anchors, the first one is placed anteriorly to preserve the greatest amount of working space possible. Next, the drill sleeve is passed through the posteroinferior cannula and placed on the humeral neck. Attention should be paid not to skive and injure the humeral head cartilage. To prevent this, the assistant may gently push against the humeral head from the anterior with a posterior-directed force. After drilling, a knotless 3.0 mm anchor is placed on the anteroinferior humeral neck by gentle impaction (Fig. 12.4). Knotless anchors

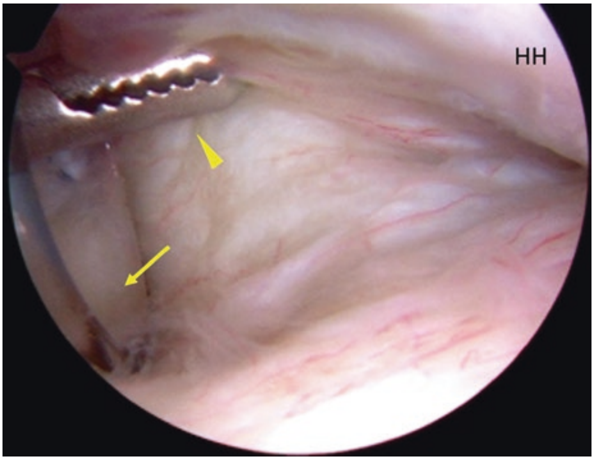

Fig. 12.3 Arthroscopic view of a left shoulder visualizing the inferior recess. Via the posteroinferior portal (arrow), an arthroscopic grasper (arrowhead) is used to reduce the capsulolabral tissue to aid in the assessment of the damage and the planning of the HAGL repair. HH = humeral head

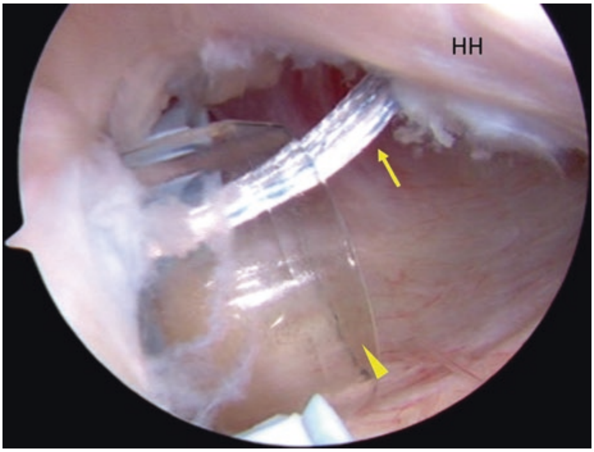

Fig. 12.4 With the arthroscope in the posterior portal of the left shoulder visualizing the inferior recess, a suture anchor (arrow) is inserted into the anteroinferior humeral neck through the posteroinferior portal (arrowhead). HH = humeral head

passed through the posteroinferior portal help prevent impingement and chondral abrasions in the glenohumeral joint. Following this, the repair suture (white-blue) is retrieved through the anterosuperior portal with a suture grasper (Fig. 12.5). A suture passer is introduced through the posteroinferior cannula and passed through the IGHL (Fig. 12.6a). A nitinol wire loop is then introduced into the joint and retrieved through the anterosuperior portal using a grasper (Fig. 12.6b). The retrieval of both the repair suture and the nitinol wire loop can be challenging due to the narrow anatomy of the humeral neck. Careful anteroinferior traction of the humeral head, as well as introducing an arthroscopic knot pusher, will aid this step.

The repair suture is loaded through the wire loop, which is pulled through the posteroinferior portal. Then, the repair suture is loaded through the loop of the shuttling suture. By pulling the free end of the blue shuttling suture, the repair suture is

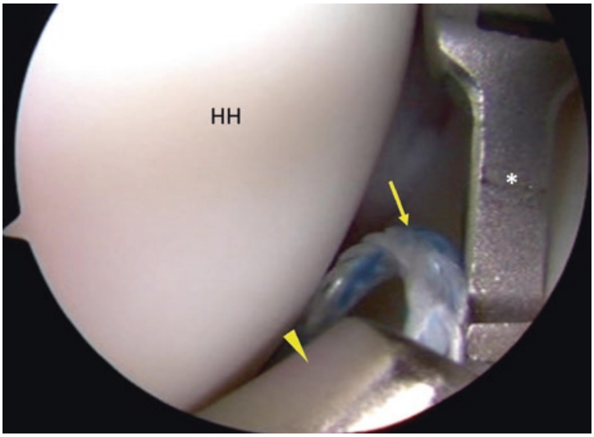

Fig. 12.5 Arthroscopic view of the left shoulder through the posterior viewing portal. From the posteroinferior portal (not visualized), the repair suture (arrow) is passed with the aid of a knot pusher (arrowhead) to an arthroscopic grasper (*) in the anterosuperior portal. The repair suture is subsequently shuttled through the anterosuperior portal (not visualized). HH = humeral head

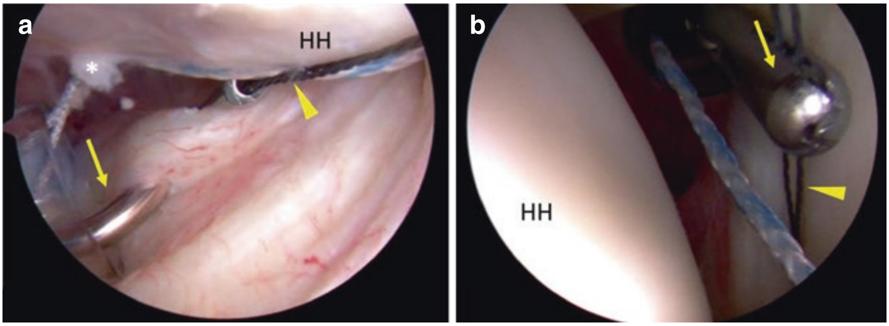

Fig. 12.6 View of the left shoulder inferior recess through the posterior viewing portal. (**a**) A curved suture passer (arrow) is passed through the capsulolabral tissue inferior to the anchor (*) to facilitate passage of a nitinol wire loop (arrowhead). (**b**) The nitinol wire loop (arrowhead) is retrieved through the anterosuperior portal using an arthroscopic grasper (arrow). HH = humeral head

shuttled back into the anchor (Fig. 12.7a). It is recommended to grab the IGHL with a grasper to achieve better positioning and to prevent over-constraint. Then, the knot is tightened to the desired tension (Fig. 12.7b) and cut with an arthroscopic suture cutter.

Placement of Additional Anchor

It may be necessary to place a second anchor for adequate fixation. In this case, the second one is placed posterolateral to the first one in the same fashion (Fig. 12.8). Finally, the stability of the final construct should be assessed by examination of the shoulder under anesthesia.

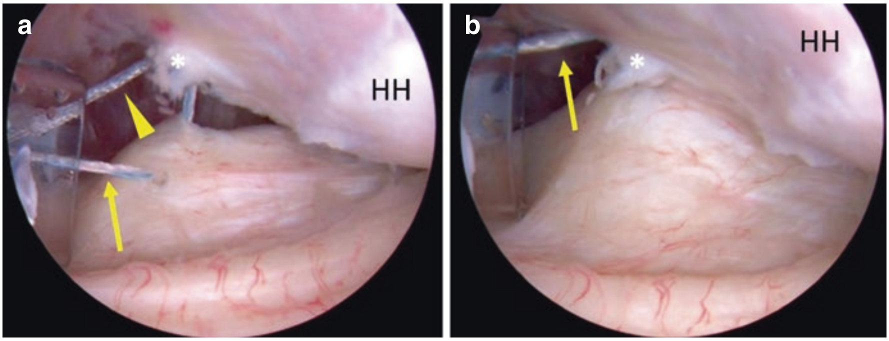

Fig. 12.7 Arthroscopic view of the left shoulder inferior recess through the posterior portal. (**a**) The repair suture (arrow) has been passed through the posteroinferior portal and is subsequently looped through the passing suture (arrowhead) and passed through the anchor (*). (**b**) Following passage of the repair suture (arrow) through the knotless anchor (*), the repair is tightened to desired tension and then cut with an arthroscopic suture cutter. HH = humeral head

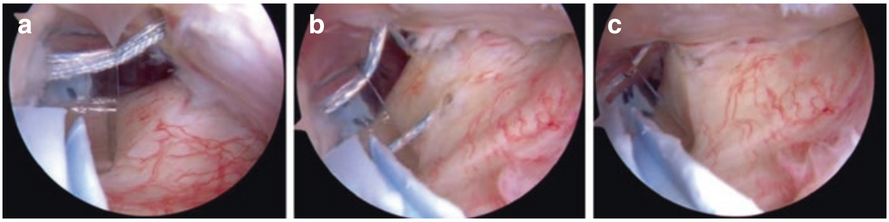

Fig. 12.8 Arthroscopic view of the second anchor placement in the left shoulder with the arthroscope in the posterior viewing portal. Following the placement of the first suture anchor, the second anchor is (**a**) placed posterolateral to the first, (**b**) passed through the capsulolabral tissue, and (**c**) tightened to desired tension

Pearls and Pitfalls

Surgical step	Pitfalls	Pearls
Diagnostic arthroscopy	Inability to visualize the HAGL lesion	Performing a thorough examination with special attention to the anterior humeral neck allows the identification
Anchor insertion	Malpositioning of the anchors, with potential damage to the cartilage of the humeral head	Insertion of anchors through the posteroinferior portal
HAGL repair	Inadequate tensioning of the capsulolabral tissue	Pulling the tissue superiorly and medially from the anterosuperior portal with a grasper before securing the knot helps control the tension of the repair
	Malreduction of the capsulolabral tissue to the glenoid	Adequate mobilization and excursion with a grasper before re-fixation

Postoperative Management

Postoperatively, the shoulder is immobilized in a sling for 6 weeks. While early passive range of motion is encouraged, it is limited to 120° of forward flexion, 90° of abduction, and 30° of external rotation in the first 3 weeks. Afterward, patients advance to full passive range of motion. Starting the seventh postoperative week, the sling is removed, and active range of motion is started. Full return of activities is usually allowed after 3 months.

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13 Anterior Instability with Bone Loss: Latarjet Procedure

Burak Altintas, Jonathan A. Godin, and Peter J. Millett

Introduction/Background

Anterior instability with significant glenoid bone loss leads to an "inverted pear" shape and results in high recurrence rates following soft tissue reconstruction alone. In these cases, augmentation of the anteroinferior glenoid with the coracoid process (Latarjet procedure) is effective in restoring glenohumeral stability and leads to good clinical outcomes.

Operative Principle

The transfer of the coracoid process with the attached conjoint tendon to the anteroinferior glenoid acts as a bone block, which increases the glenoid articular arc and thus prevents engagement of a Hill-Sachs lesion. In addition, it restores shoulder stability with the sling effect of the conjoint tendon providing dynamic reinforcement of the inferior portions of the subscapularis and the capsule. Finally, the repair of the capsule to the coracoacromial ligament remnant on the coracoid graft provides a superior shift and contributes to enhanced joint stability (Fig. 13.1).

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https://doi.org/10.1007/978-3-030-13503-4_13

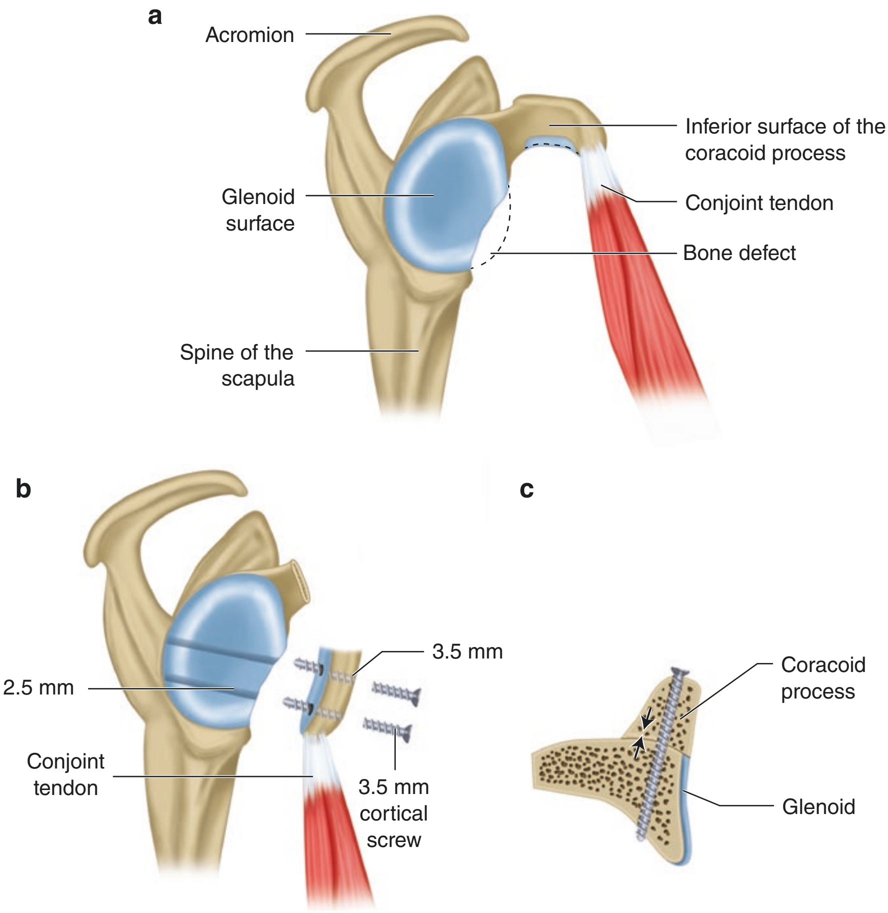

Fig. 13.1 (**a**) Illustration of a lateral view of a right shoulder with significant bone loss of the anteroinferior glenoid. (**b**) The lateral view demonstrating fixation of the osteotomized coracoid process to the glenoid with two cortical screws using a lag-screw technique. (**c**) The axial view demonstrating the coracoid process flush with the glenoid articular surface and the orientation of the screws parallel to the glenoid surface

Indications

The specific indications for the Latarjet procedure differ amongst surgeons, but it is generally indicated in patients with anterior glenohumeral instability that are unlikely to have a successful result from either an arthroscopic or open Bankart repair. More specifically, the Latarjet procedure may be indicated in patients with one or more of the following: anterior instability accompanied by significant anterior glenoid bone loss (>20%), an engaging Hill-Sachs lesion, a contact athlete, previous failed arthroscopic or open Bankart repair, or any other patient deemed to be at high risk of failure with isolated soft tissue repair.

Contraindications

The Latarjet procedure should not be performed in patients with uncontrolled epilepsy, voluntary instability, subscapularis tear, or multidirectional instability associated with generalized ligamentous laxity. Finally, in cases of bone loss, if the predicted glenoid track remains 'off track', according to the method developed by Mook and Millett, then additional procedures may be required such as a remplissage, a bipolar bone graft, or a larger glenoid bone graft from perhaps an iliac crest graft or osteoarticular allograft.

Technique

Preoperative Preparation

After the induction of general anesthesia and placement of a regional interscalene block, the patient is placed in the beach-chair position. The operative extremity is then placed in a pneumatic arm holder, and the operative shoulder and axilla are prepared and draped using standard sterile techniques.

Deltopectoral Approach

A longitudinal skin incision is carried out from the tip of the coracoid process toward the axillary crease through the skin and subcutaneous tissue (Fig. 13.2). The interval between the pectoralis major and deltoid muscles is identified. The cephalic vein should be visualized in this interval and protected by medial retraction.

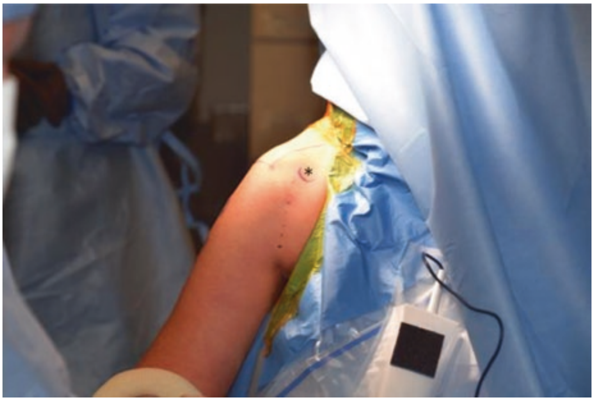

Fig. 13.2 Anterior view of a right shoulder with the patient in the beach-chair position. Note the incision extending from the tip of the coracoid process (asterisk) toward the axillary crease

Osteotomy and Preparation of the Coracoid Process

A self-retaining retractor is inserted into the wound. The coracoid process is exposed and a pointed retractor is placed along the superior aspect of the coracoid, taking care not to injure the conjoint tendon. The coracoacromial ligament is released from the lateral aspect of the coracoid, leaving approximately 5 mm of tissue attached to the coracoid for later repair. This is followed by the detachment of the pectoralis minor tendon insertion from the medial side of the coracoid. It is of utmost importance to dissect close to the medial coracoid surface as the musculocutaneous nerve lies in close proximity. Next, a Hohmann retractor is placed on each side of the coracoid (Fig. 13.3). The graft is harvested with a 90° oscillating saw from medial to lateral (Fig. 13.4).

A graft size of 25–30 mm is desirable. The mobility of the graft is enhanced through careful distal release of the conjoint tendon. Again, care must be taken to avoid injuring the musculocutaneous nerve, which lies posterior to the released pectoralis minor tendon. Next, the inferior surface of the coracoid process is skeletonized and prepared to achieve a bleeding surface for bone healing, as it is going to be positioned along the glenoid neck. Next, two 3.5 mm drill holes are placed centrally approximately 1 cm apart in the coracoid process (Fig. 13.5). The prepared coracoid graft is then placed in the inferior aspect of the wound under the pectoralis major.

Fig. 13.3 After release of the pectoralis minor tendon and coracoacromial ligament, the coracoid process (asterisk) can be visualized. Note the retractors placed medial and lateral to the coracoid process (arrows)

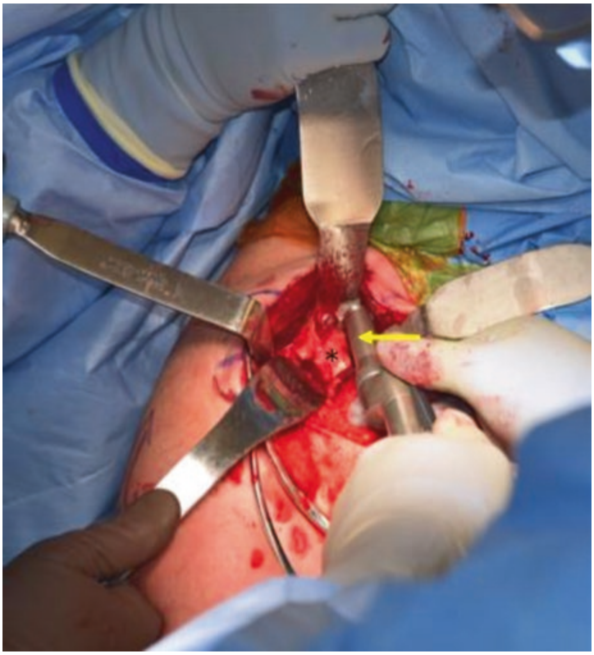

Fig. 13.4 The osteotomy of the coracoid (asterisk) is performed with a 90° oscillating saw from medial to lateral (arrow)

Glenoid Neck Exposure and Preparation

After external rotation of the arm, the upper and lower borders of the subscapularis are identified. A horizontal split is made in line with its fibers at the junction of the superior two thirds and inferior one third of the muscle. Then, the muscle is separated from the underlying capsule layer before performing a longitudinal capsulotomy. A 2 mm Kirschner wire can be inserted in the upper third of the anterior glenoid to aid the superior retraction of the upper subscapularis. The anteroinferior glenoid is visualized after placing a Fukuda retractor for lateral retraction of the humeral head and two glenoid neck retractors at the inferior and medial glenoid borders. After incising the anteroinferior labrum and periosteum with a scalpel, a 5 mm bone cutter shaver is used to create a bleeding surface of the anteroinferior glenoid rim (Fig. 13.6).

Graft Fixation

Careful lateral retraction of the humeral head with the Fukuda retractor enables the visualization of the glenoid articular surface. The inferior 2.5 mm bicortical drill hole is then placed in the glenoid rim parallel to the articular surface, taking care to note the distance between the drill hole in the coracoid and its medial edge to prevent lateral overhang of the graft (Fig. 13.7a). The depths of this screw hole and of the previously drilled hole in the coracoid are measured with a depth gauge and added to determine

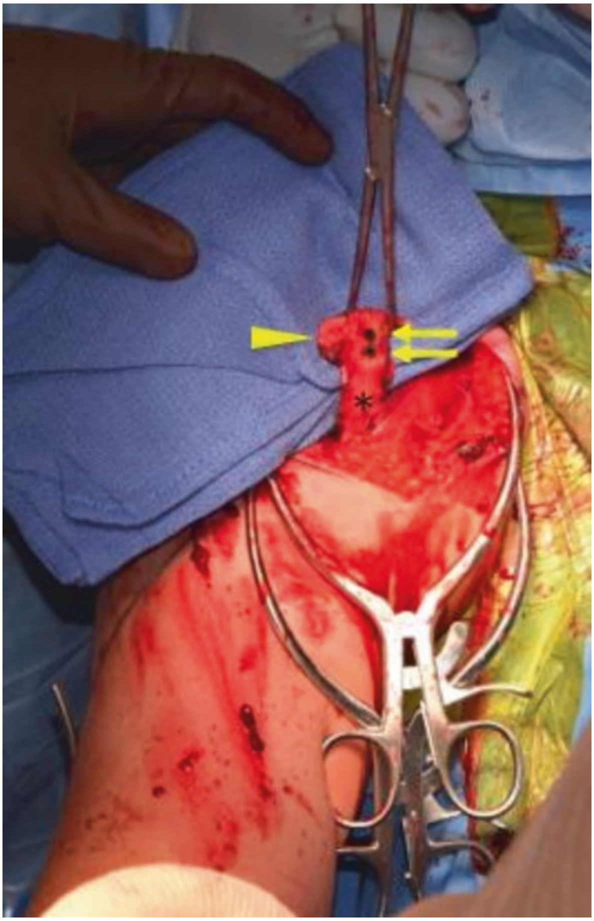

Fig. 13.5 Two 3.5 mm drill holes (arrows) are placed centrally approximately 1 cm apart in the coracoid process. Note the preserved conjoint tendon (asterisk) inferiorly and the stump of the coracoacromial ligament (arrowhead) laterally

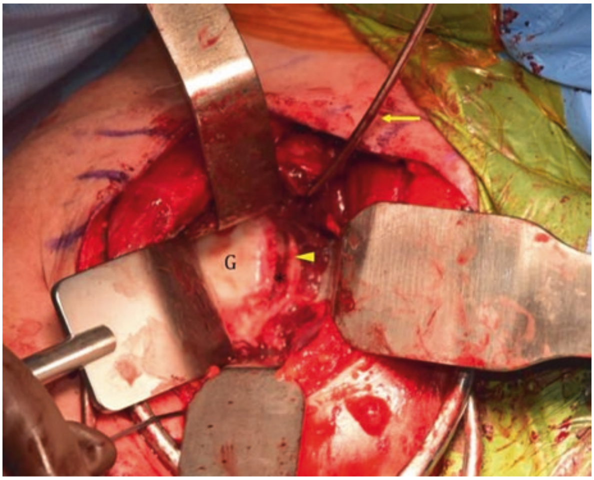

Fig. 13.6 The anteroinferior glenoid rim (asterisk) can be visualized after placing the retractors and the K-wire (arrow) as well as incising the labrum (arrowhead). (G = glenoid)

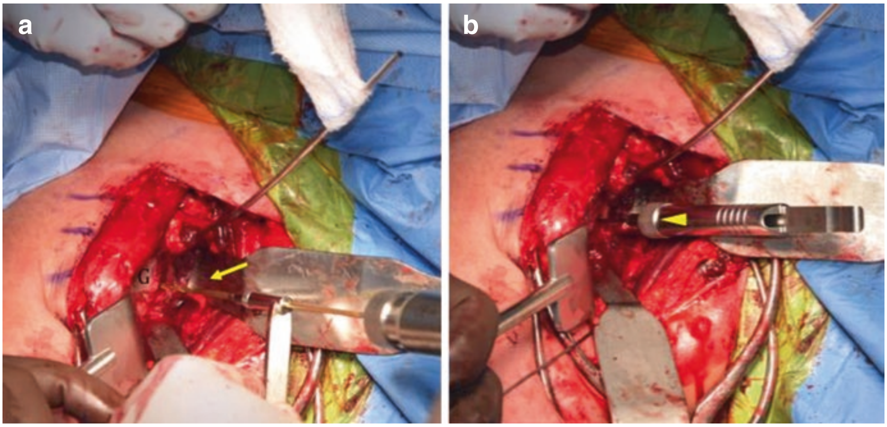

Fig. 13.7 (**a**) Drilling of a 2.5 mm bicortical hole (arrow) in the anteroinferior glenoid rim parallel to the articular surface. (**b**) Measurement of the screw hole with a depth gauge (arrowhead). (G = glenoid)

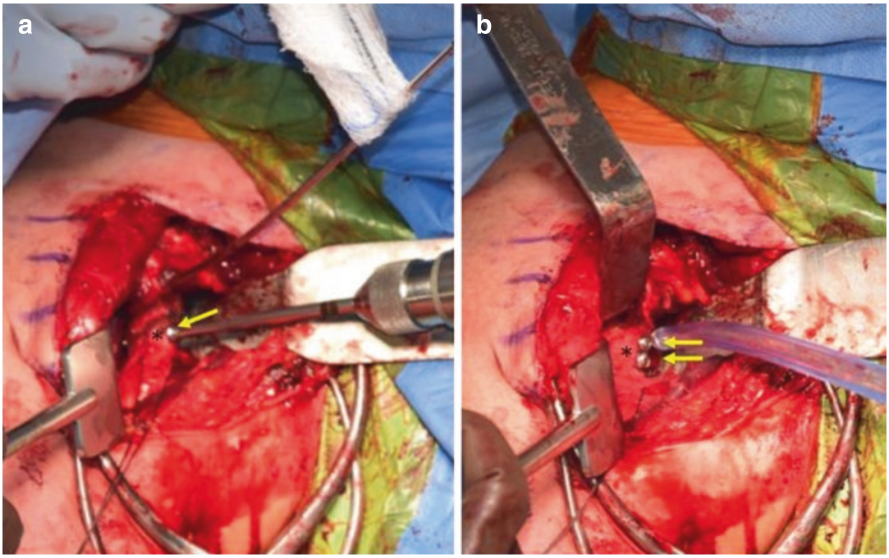

Fig. 13.8 (**a**) Insertion of the first inferior 3.5 mm cortical screw (arrow) through the coracoid process (asterisk) into the glenoid. (**b**) Stable fixation of the coracoid (asterisk) after insertion of both screws (arrows)

the length of the first fixation screw (Fig. 13.7b). After retrieving the coracoid from its position under the pectoralis major and positioning it flush with the anteroinferior glenoid, a 3.5 mm cortical screw of appropriate length is inserted (Fig. 13.8a). If positioned correctly, tightening of this screw will result in compression of the graft onto the anterior glenoid. Thereafter, the superior 3.5 mm drill hole is placed in the same fashion. After measurement of the screw length, a second 3.5 mm screw is placed for stable fixation of the coracoid to the glenoid (Fig. 13.8b).

Wound Closure

After copious irrigation, the capsule is closed while shifting the anteroinferior capsule superiorly. This is reinforced with the transferred coracoacromial ligament using multiple no. 2 non-resorbable sutures. The subscapularis split is also closed with the same suture material. The stability of the glenohumeral joint is tested at different abduction and external rotation angles. After removing the self-retaining retractors, the subcutaneous tissue is closed with 3–0 sutures, and the subcuticular layer with 4–0 absorbable sutures.

Pearls and Pitfalls

Surgical step	Pitfalls	Pearls
Surgical approach	Inability to visualize the coracoid process	After deltopectoral approach, the conjoint tendon will lead superiorly to the coracoid process
Graft preparation	Insufficient mobilization of the graft	Release the pectoralis minor tendon medially and carefully release the conjoint tendon distally. Leave a portion of the coracoacromial ligament attached to the coracoid for later repair
Glenoid exposure	Inability to visualize the anteroinferior glenoid	Perform a horizontal subscapularis split at the junction of the superior two thirds and inferior one third, and be sure the capsulotomy extends medial to the glenoid articular surface Place a Fukuda retractor to retract the humeral head and a K-wire into the anterosuperior glenoid to retract the subscapularis Introduce glenoid neck retractors inferomedially

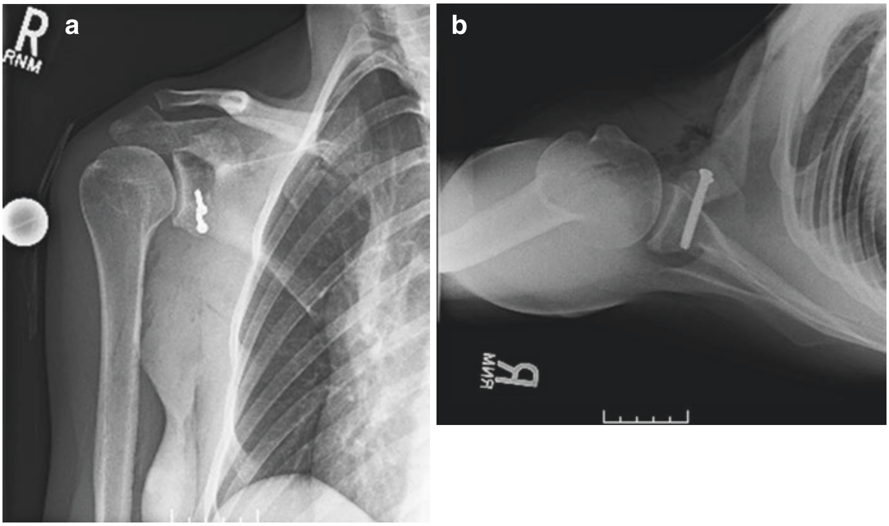

Fig. 13.9 True AP (**a**) and axillary (**b**) radiographs of the shoulder showing the correct position of the transferred coracoid process on the anteroinferior glenoid

Surgical step	Pitfalls	Pearls
Graft positioning	Lateral overhang or insufficient coverage of the anteroinferior glenoid	Position the graft flush with the anteroinferior glenoid rim before drilling
	Malreduction of the graft	Use a 3.5 mm drill bit for the coracoid process and a 2.5 mm drill bit for the glenoid for the lag-screw technique Drill both cortices of the glenoid and choose a screw of appropriate length

Postoperative Management

Radiographs of the shoulder (true AP, axillary, and Y-view) should be obtained to verify the correct position of the transferred coracoid process on the anteroinferior glenoid (Fig. 13.9a, b). The patient uses a sling for 4 weeks postoperatively. Immediate postoperative early passive range of motion is begun with a maximal external rotation of 30° during this time. Afterward, the patient is weaned from the sling while advancing to full passive, active-assisted, and active range of motion. Strengthening exercises are delayed until 3 months postoperatively. Contact sports or heavy labor is generally allowed after 6 months if complete radiological graft healing is present.

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Pancapsular Shift for Multidirectional Instability

14

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Introduction/Background

Diagnosis and management of multidirectional instability (MDI) of the shoulder remain challenging despite recent advances in basic science and clinical research to better understand glenohumeral stability. While Neer and Foster first described MDI as anterior and posterior instability associated with involuntary inferior subluxation or dislocation, the absence of standardized criteria defining MDI compounded by the need to distinguish laxity from instability underscores some of the current challenges and misconceptions of the pathoanatomy. We define MDI as symptomatic instability in two or more directions, one of which is inferior, with or without associated hyperlaxity. While rehabilitation remains the mainstay initial line of treatment, surgical intervention is reserved for those who fail an extensive nonoperative rehab regimen and should be individualized to address the anatomic causes of shoulder instability, including glenoid osteotomy, labral augmentation, and capsuloligamentous techniques. While open inferior capsular shift has been used previously attempted to reconstruct capsuloligamentous structures, advanced arthroscopic techniques, including capsular plication, are effective and less invasive options that allows the surgoen to address all areas of the

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capsule in one approach. Advantages of arthroscopic techniques include decreased morbidity, visual confirmation of the decreased capsular laxity, avoidance of subscapularis detachment, and addressal of capsular redundancies and deficiencies anteriorly, posteriorly, superioraly and in the rotator interval all through a single approach.

Operative Principle

Arthroscopic management of MDI is used to augment glenohumeral stability and improve laxity as well as repair any damaged labral tissue. Capsular plication in anterior, inferior, and posterior directions can be used to effectively reduce capsular volume incrementally through shfting the capsule or through multiple pleat techniques, which improve overall glenohumeral stability by deepening the glenoid concavity and reducing capsular laxity when combined with capsulolabral repair. Although exceedingly rare, overly aggressive plications can result in glenohumeral motion loss, particularly in external rotation. After the capsular shift, a rotator interval closure may be performed from the superior glenohumeral ligament to the middle glenohumeral ligament when abnormal laxity persists after the capsular shift. This surgery alters shoulder biomechanics by "tightening" the capsuloligamentous structures and addressing any other contributory patient-specific pathology to center the humeral head during range of motion, prevent subluxation or dislocation, and lead to additional pain relief.

Indication

Arthroscopic management of MDI is indicated in patients with symptomatic instability in multiple directions with or without associated hyperlaxity who are young and active, typically under 65 years of age, and continue to experience debilitating symptoms despite completion of an appropriate rehabilitation regimen.

Contraindications

Arthroscopic management of MDI should not be performed in patients who voluntarily dislocate their shoulder. These patients should undergo a rigorous course of non-operative management including physical therapy prior to considering surgical intervention.

Technique

Preoperative Preparation

Anesthesia includes a combination of interscalene block and general endotracheal anesthesia. The lateral decubitus position provides effective glenohumeral distraction, allowing access to the anterior and posterior glenohumeral joint, and facilitates "reduction" of the capsule-labrum onto the glenoid rim. Prior to application of traction, the examination under anesthesia is performed, assessing glenohumeral translation with the arm at 0, 45, and 90° anteriorly and posteriorly. The arm is suspended vertically with 80° of abduction and minimal forward flexion using 10–15 lb. of traction with the goal of applying uniform distraction of the glenohumeral joint.

Diagnostic Arthroscopy

A posterolateral portal is created 2 cm inferior and just medial to the lateral edge of the posterolateral acromion. This is slightly lateral to the standard arthroscopic portal and should be in line with the lateral edge of the acromion. This position will facilitate inferior labral visualization (Fig. 14.1). After the arthroscope is inserted into the posterior portal, an anterosuperior portal is developed, and a 5 mm × 7 cm cannula is inserted. This should be positioned vertically, adjacent, and distal to the clavicle, entering the capsule distal to the biceps anchor to leave adequate room for an additional 5 mm anteroinferior cannula, which should be placed just above the subscapularis tendon. To assess the posterior capsulolabral tissue (Fig. 14.2), a switching stick is utilized to reposition the arthroscope in the anterior portal for posterior visualization.

The most symptomatic side of instability should be addressed first, and, if both sides are equal, the anteroinferior labrum is addressed first as visualization in this location becomes more difficult after posterior fixation due to constraints on humeral head mobility. After assessing the extent of the labral tear, the involved tissue is mobilized with a 15° or 30° arthroscopic elevator working through the two anterior portals. Time must be taken to completely mobilize this tissue, which is often scarred and retracted onto the glenoid neck, especially in chronic situations. If visualization is not adequate anteriorly, a 70° arthroscope can be utilized for

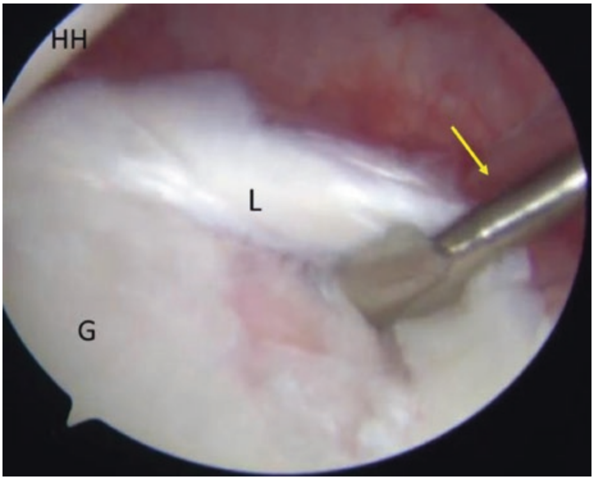

Fig. 14.1 With the patient in the lateral decubitus position, an arthroscopic view of the right shoulder through the posterior portal is shown. Using an elevator (arrow), the extent of the anteroinferior lesion of the labrum (L) is visualized. G, glenoid; HH, humeral head

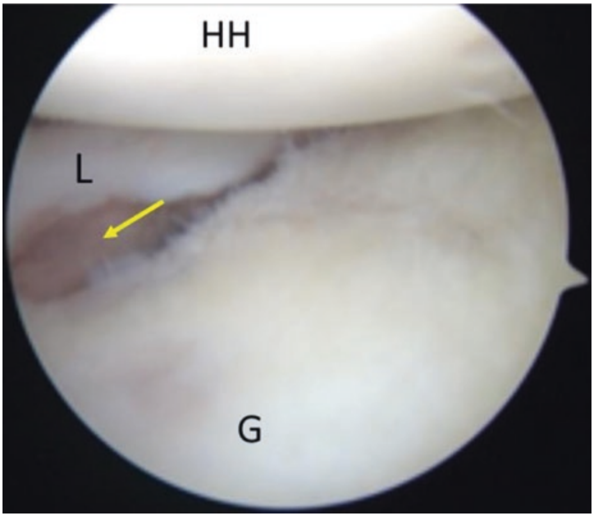

Fig. 14.2 Arthroscopic view through the anterior portal of the right shoulder in the lateral decubitus position. From this angle, damage to the posterior labrum (L) is visualized (arrow). G, glenoid; HH, humeral head

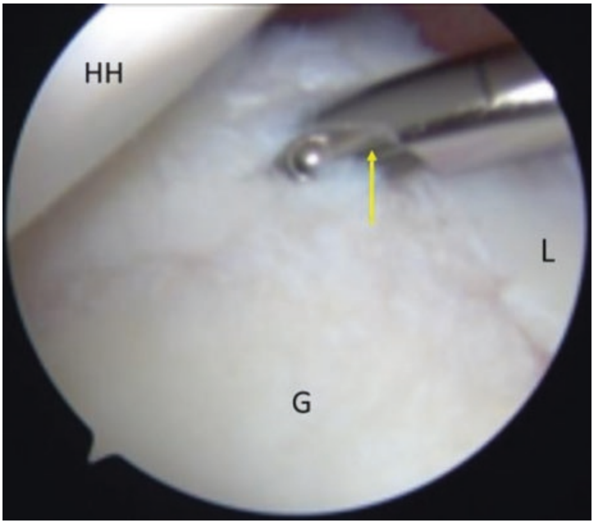

Fig. 14.3 Arthroscopic view of a right shoulder through the posterior portal. An arthroscopic shaver (arrow) is utilized to debride the glenoid bone surface and enhance biologic integration. G, glenoid; HH, humeral head; L, labrum

better assessment of retracted tissue along the glenoid neck. Visualization of the subscapularis muscle belly will often indicate sufficient mobilization. An arthroscopic shaver is then utilized to debride the glenoid bone surface and enhance biologic integration (Fig. 14.3). In the case of instability without labral disruption, the capsule is abraded with a rasp or shaver, and a capsular plication is performed to tighten the glenohumeral ligaments. If the labrum is torn, an inferior anchor is placed first using a 2.4 mm drill and drill sleeve through the inferior cannula. The sleeve should be directed to the chondrolabral interface at 5 o'clock position, 1–2 mm off the face of glenoid. Once the position on the face is secured, while applying downward pressure, the drill sleeve can be utilized to displace the humeral head posteriorly, in order to shift from a more horizontal to vertical trajectory, which facilitates proper anchor positioning on the glenoid rim. This maneuver helps to avoid horizontal insertion of the anchor which risks positioning the implant within the substance of the cartilage above the underlying subchondral bone. Once position and trajectory are ideal, insert the drill into the sleeve ensuring the chondral surface is not violated. When hard bone is encountered, the drill is cycled in and out two to three times to ensure shavings and debris are removed from the hole. The drill is removed, and the 3 mm anchor is inserted into the sleeve in the same trajectory as it was previously drilled. Manual insertion of the anchor into the sleeve approximately one-third of the way prior to hammering ensures a correct trajectory to avoid anchor breakage. The anchor is then malleted into its appropriate position within the bone. The inserter handle is removed, and traction is then placed on the anchor to test its stability within the bone. If the anchor fails or pulls out a larger diameter, a 3.7 mm anchor can be used. We prefer to use knotless anchors to minimize the risk of abrasion on the humeral articular surface. The planned post limb of the repair suture is retrieved through the anterosuperior portal with a suture grasper. A 25° angled curved shuttling device is used to pass around the anteroinferior labrum at or near the level of the anchor. In a right shoulder, the device must be angled to the right to facilitate ideal trajectory of the suture within the anterior capsulolabral complex. The device is inserted into the anteroinferior capsule 1–2 mm anterior and inferior to the anchor with the tip inserted perpendicular to the tissue. After the capsule is penetrated, the device is rotated 90° by rotating your wrist one-half turn counterclockwise and pushing into the glenoid neck while avoiding overrotation of your wrist in order to penetrate the labrum and present the shuttling device at the chondrolabral junction. The shuttling suture should exit above the level of the anchor so that the capsule will be shifted not only from lateral to medial but also from inferior to superior. The goal is to shift the capsule from medial to lateral and from inferior to superior.

The nitinol shuttling wire is then looped into the joint and retrieved from the anterosuperior portal. The repair suture is then loaded through the nitinol loop and delivered through the anterosuperior cannula by retracting the nitinol wire anteriorly. Continued retraction of the nitinol will deliver the repair suture through the labrum and capsule. The suture is then shuttled out of the joint through the anteroinferior cannula by continuing to gently pull the shuttling nitinol wire. The repair suture is then loaded through the loop end of the shuttling suture and secured with one hand. The free end of the shuttling suture is then pulled to shuttle the repair suture back into the anchor. Advance the shuttle suture with repeated gentle tugs until the repair suture is passed through the locking mechanism and out of the cannula. The free end of the repair suture can then be tightened until desired tension is achieved. The suture is cut flush with the tissue (Fig. 14.4).

The same process is completed at the 4 o'clock position. After two inferior anchors are placed anteriorly, posterior repair is initiated. Using a switching stick, the arthroscope is repositioned in the anterosuperior portal. Under direct visualization, a posterolateral portal is developed, and a 5.0 mm × 7 cm cannula is placed for anchor

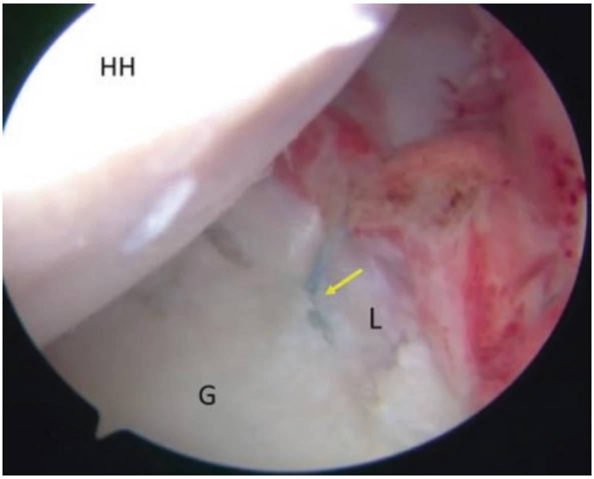

Fig. 14.4 Arthroscopic view of a right shoulder through the posterior portal. View of the anteroinferior anchor (arrow) after completed placement and capsulolabral shift. G, glenoid; HH, humeral head; L, labrum

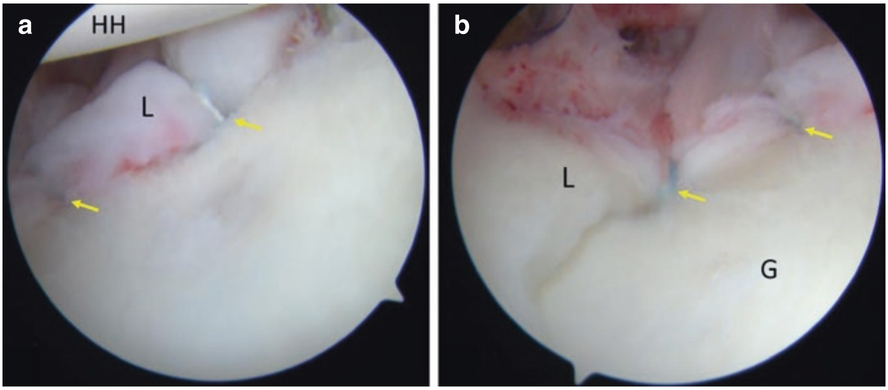

Fig. 14.5 Arthroscopic view of a right shoulder in the lateral decubitus position through the anterior portal. View of the superior (**a**) and inferior (**b**) posterior glenoid and labrum following completed anchor placement (arrows) and capsulolabral shift. G, glenoid; HH, humeral head; L, labrum

placement and suture shuttling. Starting at the 7 o'clock position, four anchors are placed from inferior to superior in a similar fashion to the previously placed anterior anchors while shifting the capsule 1–2 mm superiorly with the inferior two anchors (Fig. 14.5). A low-profile shuttling device that fits through the 5 mm cannula is used to pass the posterior sutures. This shuttling device allows for a larger shift and allows for the use of only a 5 mm cannula which disrupts the posterior capsule less and takes up less space, thus allowing for easier manipulation of the tissues. A larger shift is especially important for patients with severe capsular laxity and a patulous posterior capsule or those with increased glenoid retroversion.

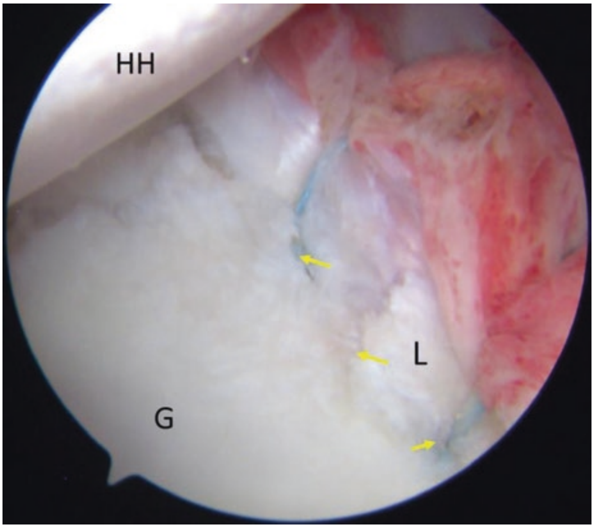

Fig. 14.6 Arthroscopic view of a right shoulder through the posterior portal. View of the anterior anchors (arrow) after completed placement and capsulolabral shift. G, glenoid; HH, humeral head; L, labrum

After the labral repair is complete, the cannula is removed, and the working posterior portal can be closed using a # 2 absorbable suture to enhance capsular integrity. This is performed first by shuttling the suture through the capsule proximal to the portal with the shuttling device. Next, a 2.7 mm 22° penetrating suture retriever is passed through the capsule distal to the portal, and the suture is retrieved and delivered out of the joint through the cannula where it is tied creating an outside-in capsular repair, without incorporating any rotator cuff or deltoid fibers. The arthroscope is repositioned into the original posterior viewing portal, and additional anterior anchors can be placed to complete the repair as needed (Fig. 14.6).

Pearls and Pitfalls of Surgical Technique

Place your initial portal in-line with the lateral edge of the acromion and slightly inferior for access to the inferior labrum	When drilling, stabilize the drill sleeve with the contralateral non-drilling hand to avoid skiving
The initial anterior portal should be placed as superior as possible with a vertical trajectory which enters the capsule just distal to the biceps anchor, aiming toward the 5 o'clock position, leaving adequate space for a second anterior portal	Incorrect anterior portal placement can make instrumentation difficult, lead to cannula interference, and negatively impact suture anchor trajectory, thereby risking hardware failure
The anteroinferior labrum is usually the most critical for stability and the most difficult area to access. When planning a panlabral repair, the anteroinferior labrum should generally be addressed first	

When placing anterior suture anchors, use the arthroscope and rigid cannula sleeve to lever the humeral head posteriorly for improved visualization and facilitate proper anchor position	When drilling for anchor placement, the sleeve should be placed 1–2 mm on the glenoid face to avoid skiving. Ensure you are angled enough to obtain appropriate bony purchase to avoid subchondral placement
If the anchor fails or pulls out due to poor bone quality, a larger diameter 3.7 mm suture anchor can be used	When using a knotless repair system, utilize your accessory cannulas to avoid tethering of the suture material which can interfere with shuttling and the locking mechanism
After posterior labral repair is complete, the posterior portal can be closed with PDS suture to enhance capsular integrity	

Postoperative Management

Each postoperative rehabilitation profile should be individualized and based on the robustness of the repair. The shoulder is placed in approximately neutral rotation for 4–6 weeks with strict immobilization in an abduction pillow. The rehabilitation goals of these first 6 weeks include protecting the surgical repair, minimizing pain and inflammation, maintaining mobility of accessory joints (fingers, wrist, elbow), and providing patient education. The immobilization period is individualized based on the postoperative clinical evaluation. Therapy should be initiated if the shoulder becomes stiff. If the glenohumeral joint remains supple, longer periods of immobilization are used. Once the immobilizer has been discontinued, patients begin strengthening exercises targeting shoulder musculature. Patients are allowed to return to full activity approximately 6 months postoperatively if they demonstrate full strength and have completed a sport-specific training program.

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Posterior Instability

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Introduction/Background

Posterior instability with associated labral pathology is an often subtle finding and frequently missed diagnosis that encompasses a broad spectrum of pathoanatomy affecting the capsulolabral soft tissue and bony architecture of the shoulder with subtle, nonspecific clinical findings. Management is further complicated by the multifactorial nature of posterior instability and combination of various pathoanatomy including posterior Bankart lesion, excessive capsulolabral laxity, glenoid erosion, and glenoid retroversion. Physical therapy centered on strengthening the dynamic muscular stabilizers to compensate for deficient static stabilizers remains the first line of treatment and can be successful in 60–85% of cases. Surgery, however, is best reserved for those who fail non-operative management and experience recurrent, posttraumatic, unidirectional subluxation.

Procedures addressing posterior instability may be subdivided into soft tissue and bony procedures. Soft tissue procedures without bone loss for posterior instability include advanced arthroscopic posterior stabilization techniques that address both traumatic and atraumatic instability, including reverse Bankart lesions,

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posterior humeral avulsion of the glenohumeral ligament, and reverse Hill-Sachs lesions (i.e., modified McLaughlin technique). Procedures for posterior instability with bone loss in the setting of glenoid dysplasia or retroversion include an opening wedge glenoid osteotomy and bony augmentation procedures including an osteochondral tibial allograft.

Operative Principle

In the management of posterior instability without bone loss, arthroscopic posterior stabilization may be used to address capsulolabral injury and posterior humeral avulsion of the glenohumeral ligament with suture anchors and capsular redundancy with a posterior capsular shift. Among patients with a reverse Hill-Sachs defect, the modified arthroscopic McLaughlin procedure allows for filling of the bony defect with the subscapularis tendon by creating a double-mattress suture that provides a large footprint for the subscapularis and a broad surface for tendon-to-bone healing. Furthermore, this technique avoids detaching the subscapularis and the morbidity of open procedures. For patients with posterior instability in the setting of bone loss, an opening wedge posterior glenoid osteotomy or glenoid augmentation with autograft or allograft is required to restore the glenoid arc and buttress the humeral head.

Indication

Surgical intervention for posterior instability with or without bone loss is indicated when conservative treatment fails and is most successful among patients with recurrent, posttraumatic, and unidirectional subluxation. Arthroscopic posterior stabilization is indicated for patients without bone loss and with posterior capsulolabral pathologies, including Bankart lesions, capsulolabral laxity, posterior humeral avulsion of glenohumeral ligament, and reverse Hill-Sachs lesions. Open techniques for posterior instability with bone loss, specifically opening wedge posterior glenoid osteotomy, are indicated in the setting of glenoid dysplasia, erosion, or retroversion typically greater than 20°.

Contraindications

Surgical management is contraindicated among voluntary dislocators. Absolute contraindications to arthroscopic management of posterior instability include significant glenoid bone loss or retroversion typically greater than 20°.

Technique

Reverse Bankart Repair Using Knotless Anchors.

The authors prefer the beach chair position for most posterior labral repairs. The lateral decubitus position may be used if a U-shaped inferior tear is suspected for better access to the 6 and 7 o'clock positions. After proper setup, detailed in a previous chapter, the initial viewing portal is developed 2 cm inferior and lateral to the standard diagnostic portal, in line or slightly lateral to the posterolateral edge of the acromion. This portal placement is critical for access during instrumentation and fixation; if placed correctly, the portal can be utilized during the repair to avoid additional damage to the capsular tissue. After placement of the viewing portal and insertion of the arthroscope, an anterosuperior portal is developed under visualization using spinal needle localization to target the superior medial rotator interval tissue, just inferior to the biceps anchor. After optimal position is confirmed, a 5 mm × 7 cm cannula is inserted. The portal should be directed in a vertical direction and enter the skin just inferior to the clavicle but superior and lateral to the coracoid to facilitate visualization of the labrum in its entirety.

Next, a standard diagnostic arthroscopy is performed, ensuring no pathology is present in the anterior, superior, and inferior labral tissue, as well as long head of the biceps or articular rotator cuff. After the anterior glenohumeral structures are assessed, a switching stick is utilized to reposition the arthroscope into the anterosuperior portal to assess the posterior labral injury (Fig. 15.1). It is important to understand the extent of each tear and to identify any capsular rents or avulsions from the humeral head as these must be addressed during the repair. If the tear extends anterior and inferior, this repair should be performed prior to the posterior stabilization for visualization purposes. A second portal is placed anteriorly through the rotator interval. This portal is placed parallel to the glenoid and will be used to shuttle sutures anterior to posterior as the posterior capsulolabral repair occurs.

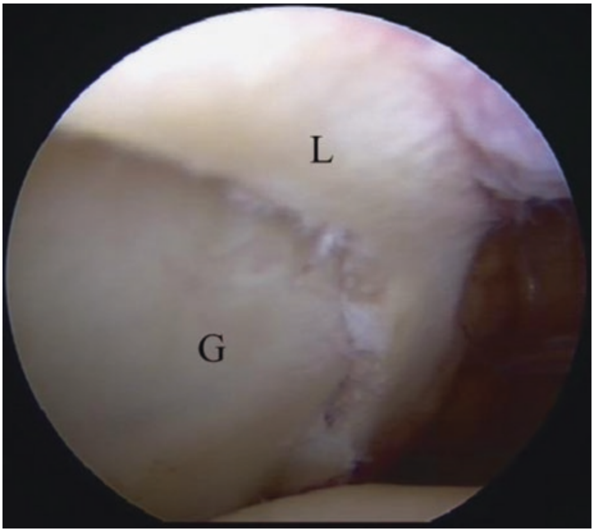

Fig. 15.1 Arthroscopic view of a left shoulder through the anterolateral portal. The lesion of the posterior labrum is visualized here. G, glenoid; L, labrum

Next, a posterolateral working portal is developed using the spinal needle to ensure adequate access to the extent of the tear. After optimal position is identified and localized, a 5.0 mm × 7 cm cannula is placed. This will be utilized for labral mobilization, anchor placement, and suture shuttling. Using direct visualization, an additional posteroinferior portal can be developed to assist in anchor placement and suture shuttling, resulting in two working portals posteriorly (Fig. 15.2). The tear is then mobilized with a 15° or 30° arthroscopic elevator working through the posterolateral portal until it is completely released from its adherent position on the glenoid neck. An arthroscopic shaver is then used to debride the glenoid bone surface under the tear to enhance biologic integration,

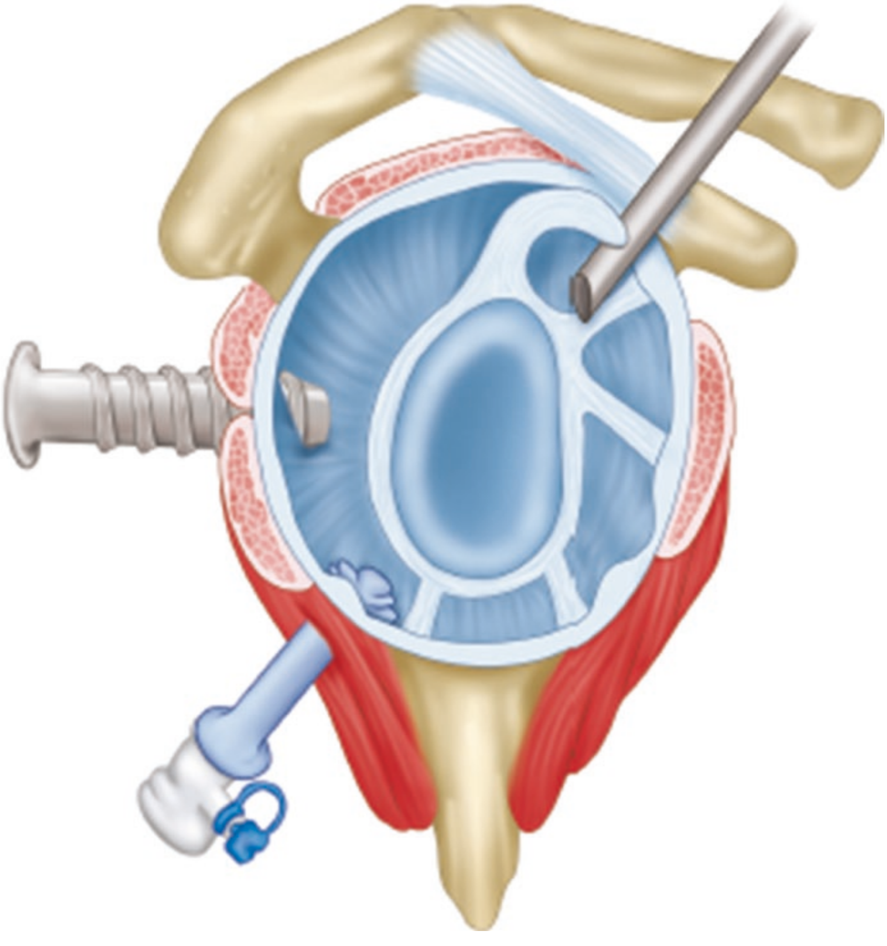

Fig. 15.2 Sagittal cut of a right shoulder demonstrating the arthroscope in the anterosuperior viewing portal (A). Two working portals, posteroinferior (B) and posterosuperior (C), are developed under direct visualization, and cannulas are placed for anchor placement and suture management

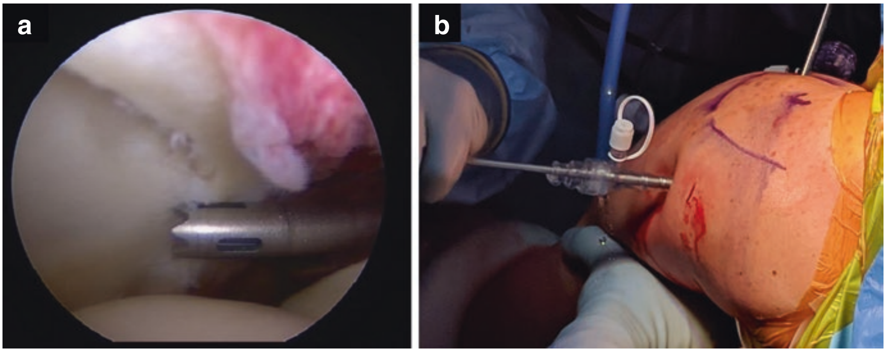

Fig. 15.3 View of placement of the first anchor into the posteroinferior labrum. (**a**) Arthroscopic view through the anterolateral portal of the drill guide begin placed on the posterior inferior glenoid for suture anchor placement. (**b**) External view of the shoulder demonstrating the placement of the arthroscope in the anterolateral portal and drill guide in the posteroinferior portal for this step

avoiding any resection of the marginal articular cartilage and bone. For labral tissue with significant adhesions and retraction onto the glenoid neck, the arthroscopic wand can be utilized along with an elevator to ensure complete mobilization of the tissue. This is critical for restoration of the labral bumper.

The most inferior anchor is placed first (Fig. 15.3) using a 2.4 mm drill and drill sleeve through the posterior cannula. The rigid sleeve should be angled, so the drill engages into subcortical bone. When access is difficult inferiorly, the sleeve can act a lever on the humeral head, distracting it anterior and inferiorly, so the optimal angle can be achieved. This can be achieved by applying downward pressure to the drill sleeve while raising it from the horizontal trajectory to a more vertical one. If the angle is too perpendicular to the chondral surface, the anchor is at risk for placement within the chondral tissue which can result in chondral penetration, symptomatic hardware, and humeral-sided chondrolysis. When hard bone is encountered, the drill is cycled in and out two to three times to ensure shavings and debris are removed from the hole. It is important during this process to stabilize the drill sleeve with the contralateral non-drilling hand to avoid skiving and keep the position of the sleeve as you transition from the drill to anchor placement, especially when you are levering the humeral head.

After the pilot hole is drilled, a 3 mm anchor is inserted. The anchor is initially guided into the drill hole by hand approximately one-third of the way prior to hammering; this ensures the correct anchor trajectory is obtained and avoids suture anchor damage. The anchor is malleted into its appropriate depth in the bone using the instrument guide to confirm appropriate depth into the subchondral bone. The sutures are then released from the anchor-inserter handle, and the inserter is gently removed with combined rotation and in-line traction (Fig. 15.4). Be sure not to deviate from the anchor trajectory while removing the instrument as deviation could result in suture compromise, difficulty with removal of

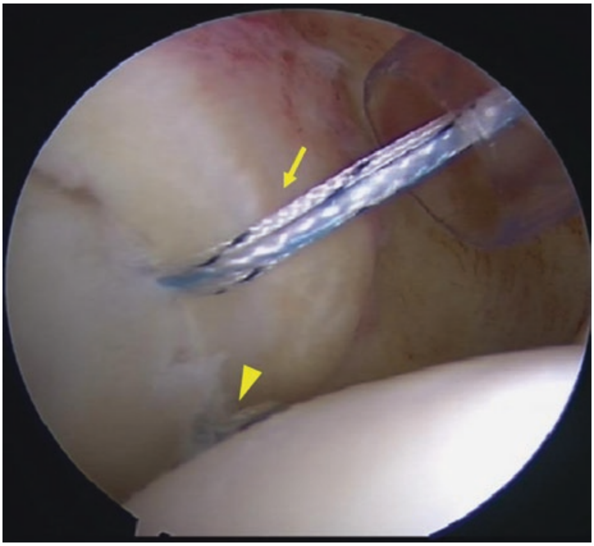

Fig. 15.4 Arthroscopic view through the anterolateral portal demonstrating the placement of the second suture anchor (arrow). Note that the first suture anchor has already been placed (arrowhead)

instrumentation, and pullout of the previously seeded anchor. The suture anchor is then shucked to confirm fixation within the subchondral bone prior to labral incorporation. In revision cases with prior anchor material, anchors that appear loose or are within poor bone quality, a larger SutureTak anchor can be placed (3.7 mm or larger) and can be utilized to gain purchase. Anchor selection is based on surgeon preference and experience; however, we prefer to use knotless anchors to minimize the risk of suture-induced humeral chondrolysis.

Using the Arthrex knotless system, the repair suture is initially retrieved through an accessory portal with a suture grasper. This accessory portal which may be anterior or posterior depending on tear characteristics and concomitant pathologies being addressed is used for shuttling and suture management for the posterior repair. A semilunar tissue penetrator and shuttling device is inserted in the posterosuperior cannula to pass around the posteroinferior labrum near the level of the anchor (Fig. 15.5). To avoid the necessity of inserting a larger cannula, a low-profile shuttling device that fits through the 5 mm cannula is used to pass the posterior sutures. This shuttling device allows for a larger shift and allows for the use of only a 5 mm cannula which disrupts the posterior capsule less and takes up less space, thus allowing for easier manipulation of the tissues. The lasso should incorporate the surrounding capsular tissue if capsulorrhaphy is desired with the goal of shifting the capsule from posterolateral and inferior to posteromedial and superior position. A larger shift is especially important for patients with severe capsular laxity and a patulous posterior capsule or those with increased

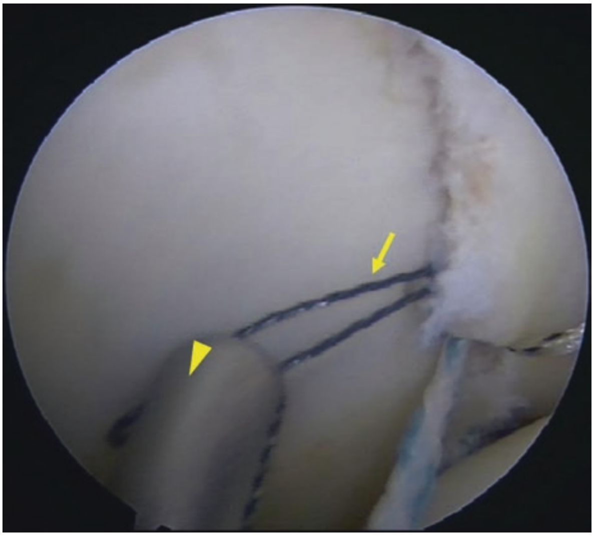

Fig. 15.5 Arthroscopic view of the left shoulder posterior labrum via the anterolateral portal. Through the posterior portal, a tissue-penetrating device has been passed through the capsulolabral tissue, and the nitinol wire (arrow) is deployed through the device. Via the anterior portal, an arthroscopic grasper (arrowhead) is used to retrieve the nitinol wire through the same portal as the repair suture in the previous step

glenoid retroversion. The shuttling device is inserted perpendicular to the tissue to penetrate the labrum at the chondrolabral junction to facilitate shuttling of the repair suture. Nitinol wire from the shuttling device is then looped into the joint and retrieved from accessory cannula that houses the repair suture.

Next, the repair suture is then loaded through the nitinol loop and delivered through the posterior cannula by retracting the nitinol wire from the cannula posteriorly, delivering the repair suture through the labrum and capsule and out of the joint through the posterosuperior cannula. This results in three limbs of the anchor exiting through the posterosuperior cannula: the repair stitch, the non-looped shuttling suture, and the looped end shuttling suture. To avoid tangling of the repair suture, the non-looped end of the shuttling suture is retrieved through the accessory portal, leaving the looped end and repair suture in the posterosuperior cannula. Next the repair suture is loaded through the loop end of the shuttling suture and secured with slight tension to ensure in-line trajectory through the shuttling process. Next, the non-looped end of the shuttling suture is pulled with the opposite hand to shuttle the repair suture back through the locking mechanism of the anchor to achieve fixation. The free end of the repair suture can be tightened until desired tension is achieved. The suture is then cut flush with the tissue (Fig. 15.6). This can be repeated for additional anchor placement with the goal of restoring labral integrity and reduction of capsular laxity.

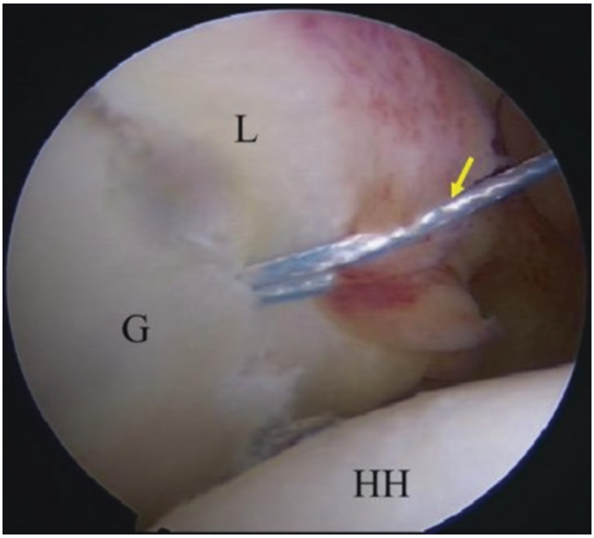

Fig. 15.6 Arthroscopic view through the anterolateral portal of the posterior labrum. Following passage of the repair suture (arrow) through the capsulolabral tissue and suture anchor, the suture is tensioned appropriately. If desired, a tissue grasper may also be used via the anterior portal to further shift the capsulolabral tissue during the tensioning step

Pearls and Pitfalls

Surgical step	Pitfalls	Pearls
Diagnostic arthroscopy	Missing concomitant lesions	Performing a thorough and standardized examination allows for identification of concomitant lesions
Labral preparation and release	Improper restoration of the labral bumper due to inadequate release of adhesions and contracted tissue from the glenoid neck	Have a skilled assistant hold the camera, in order to manipulate tissue with one hand while releasing with the electrocautery device with the other. Ensure the device is in contact with the glenoid bone at all times to avoid iatrogenic injury to the labral tissue
Anchor placement	Placement of posterior anchors prior to anterior inferior anchors, resulting in limited exposure	Always asses the entire labrum and address any anterior extension prior to posterior fixation. A tight posterior capsule will limit your ability to subluxate and lever the humeral head for placement of the anterior inferior anchor
Knotless anchor shuttling	Bunching or catching of the repair stitch during the shuttling with the shuttling suture	Utilize an accessory cannula to deliver the non-looped end of the shuttling suture, so you are not pulling three sutures through the same cannula. This extra step can avoid issues with premature locking or bunching of the suture material as you shuttle the repair suture through the locking mechanism

Postoperative Management

Immediately following surgery, patients require an orthosis to maintain abduction, neutral rotation, and extension of the shoulder. The elbow should be positioned posterior to the coronal plane of the body to decrease tension on the repair. Immobilization is maintained from 4 to 6 weeks depending on the pathoanatomy, quality of the tissue, and strength of the repair. After 6 weeks, a program of active assisted range of motion exercises is begun. Strengthening exercises are initiated 3 months postoperatively, and all contact sports are avoided up to 6 months.

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Part IV

Biceps Tendon Pathologies

Proximal Biceps Pathologies: SLAP Lesions, Pulley Lesions, and Biceps Tenosynovitis

16

J. Christoph Katthagen and Peter J. Millett

Introduction/Background

Instabilities of the intra-articular portion of the long head of the biceps tendon due to SLAP (superior labrum anterior to posterior) and BRP (biceps reflection pulley) lesions as well as chronic tenosynovitis in the region of the bicipital groove often lead to anterior shoulder pain, limited shoulder function, and reduced quality of life.

The long head of the biceps (LHB) tendon originates from the supraglenoid tubercle together with the superior labrum. Instabilities of the so-called biceps anchor are classified as SLAP lesions according to Snyder and Maffet (Fig. 16.1). Fraying of the biceps anchor (SLAP I lesion) and buckle handle tears of the labrum without extension into the LHB tendon (SLAP III lesion) can usually be treated by debridement. Unstable SLAP lesions are acknowledged risk factors for the development of glenohumeral arthritis. The treatment of unstable SLAP lesions with participation of the LHB tendon therefore typically consists of repair of the labrum with or without tenotomy and subpectoral tenodesis of the LHB.

The LHB tendon exits the glenohumeral joint via the bicipital groove. The soft tissue sling that stabilizes the LHB tendon at the entry of the sulcus is the so-called biceps reflection pulley (BRP). The BRP is built by fibers of the coracohumeral ligament, the superior glenohumeral ligament, the subscapularis, and the supraspinatus tendons. BRP lesions are classified according to Bennett and most commonly result in a medial instability of the LHB tendon (Fig. 16.2). BRP lesions are often associated with anterosuperior rotator cuff tears and subcoracoid impingement. BRP lesions

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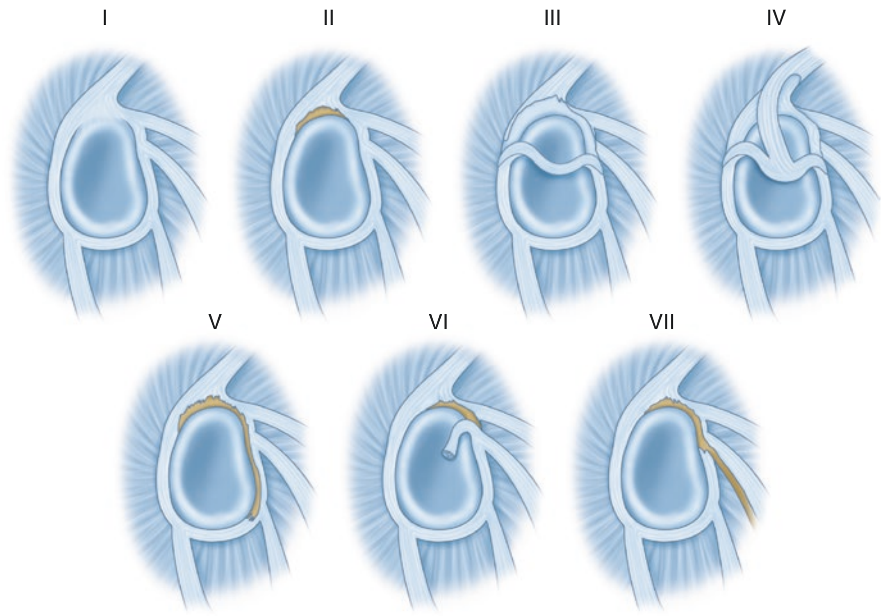


Fig. 16.1 Classification of SLAP lesions according to Snyder (types I–IV) and Maffet (types V–VII); type I, fraying of the labrum, biceps anchor intact; type II, superior labrum and biceps tendon detached from the superior glenoid; type III, buckle handle tear of the superior labrum, biceps tendon attached to superior glenoid; type IV, buckle handle tear of the superior labrum extending longitudinally into the biceps tendon; type V, anterior inferior labrum detached with biceps tendon detached; type VI, unstable flap tear of the superior labrum with detached biceps anchor; type VII, anterior superior labrum detached extending beneath the middle glenohumeral ligament with detached biceps anchor

often result in biceps chondromalacia of the anterosuperior parts of the humeral head. Since repair of symptomatic BRP lesions results in unsatisfying clinical outcomes in a fair portion of patients, the recommended treatment of choice is an intra-articular tenotomy of the LHB tendon with subsequent subpectoral tenodesis.

Within the bicipital groove, the LHB tendon can be painfully inflamed resulting in biceps tenosynovitis. A typical MRI sign of tenosynovitis is the halo sign with inflammatory fluid surrounding the LHB tendon in transversal T2-weighed MRI images. In cases of failed non-operative management, intra-articular tenotomy and subpectoral tenodesis with resection of the inflamed portion of the LHB tendon lead to excellent clinical outcomes.

Operative Principle

The operative principle for the treatment of BRP lesions as well as LHB tenosynovitis consists of resection of the intra-articular portion of the LHB and extraarticular subpectoral refixation of the remaining tendon to the proximal humerus. For SLAP

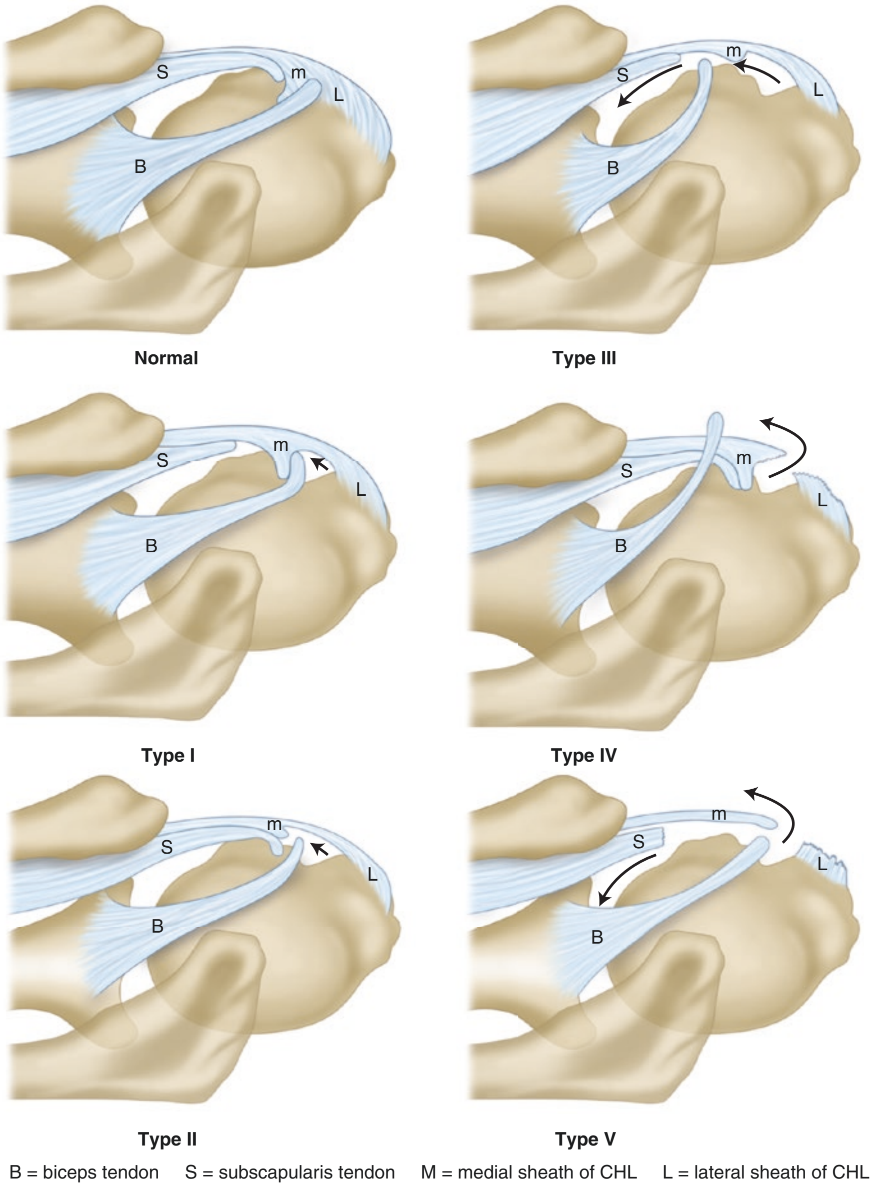


Fig. 16.2 Classification of biceps reflection pulley lesions according to Bennett: type I, injury of the intra-articular subscapularis tendon without involvement of the medial head of coracohumeral ligament (CHL); type II, injury of the medial sheath (composed of SGHL-medial CHL ligament complex), without subscapularis involvement; type III, injury involving both the medial sheath and subscapularis tendon; type IV, injury involving the supraspinatus and lateral head of CHL; type V, injury involving all structures, intra-articular subscapularis tendon, medial sheath, supraspinatus tendon, and lateral CHL

lesions, unstable parts of the labrum and the biceps anchor are repaired by knotless anchor refixation at its origin. If the LHB tendon shows degenerative changes, partial ruptures, or tenosynovitis and in patients older than 35 years, a concomitant subpectoral biceps tenodesis is recommended after repair of the labrum.

Indication

Intra-articular LHB tenotomy and subpectoral LHB tenodesis are indicated in patients with all types of symptomatic BRP lesions and in patients with LHB tenosynovitis with failure of non-operative treatment. For SLAP lesions type II and IV according to Snyder and in SLAP lesions type V to VII according to Maffet (Fig. 16.1), the abovementioned operative principles apply.

Contraindications

Contraindications for subpectoral tenodesis of the LHB tendon include bony pathologies of the proximal humerus with reduced fixation stability (e.g., bone tumors, metastasis, and acute fractures). Finally, as with all elective surgery, significant general medical comorbidities including cardiac disease, pulmonary disease, and active infection are contraindications to biceps tenodesis.

Technique

Preoperative Preparation

After the induction of general anesthesia and placement of a regional interscalene block, the patient is placed in the beach chair position. The operative extremity is then situated in a pneumatic arm holder, and the operative shoulder and axilla are prepared and draped using standard sterile techniques.

LHB Tenotomy and Subpectoral Tenodesis

If LHB tenotomy and subpectoral tenodesis are performed as isolated procedure, standard posterior and anterior working portals are established. A 5 mm × 7 cm cannula is inserted in the anterior working portal. First, after confirmation of the indication for the procedure, the LHB is cut at its origin directly adjacent to the glenoidal labrum with the radiofrequency probe (Fig. 16.3). Next, eventual fraying of the labrum is debrided. In case of BRP lesions, tears of the subscapularis and/or supraspinatus may need to be treated (see Sections "Operative Principle" and "Indication").

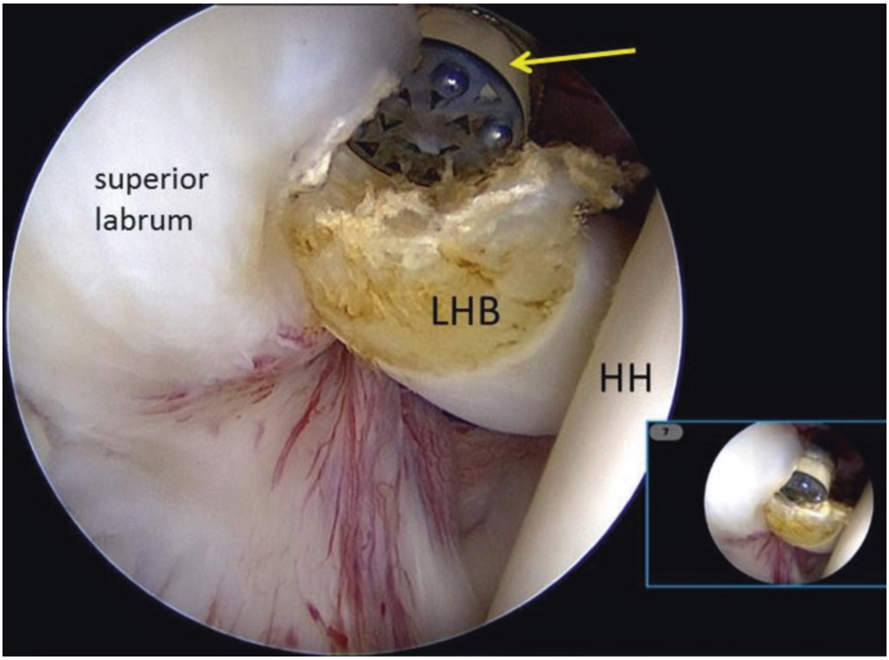


Fig. 16.3 Arthroscopic view of a right shoulder through the posterior portal. Tenotomy of the long head of the biceps (LHB) tendon with a radiofrequency probe (yellow arrow) at its origin at the superior labrum; HH humeral head

Once glenohumeral and subacromial arthroscopy are finished, the arm is placed in 40–50° of external rotation and 70–80° of abduction (Fig. 16.4). The axillary crease and the inferior border of the pectoralis major tendon are marked with a sterile pen (Fig. 16.5), and a 2–3 cm incision is made in the axillary crease starting inferior from the crossing point of the abovementioned lines.

Next, the interval between the inferior border of the pectoralis major and the short head of the biceps needs to be identified. The inferior border is elevated with an army-navy retractor (Fig. 16.6). The fascia layer between the pectoralis major and the short head of the biceps is cut, and the long head of the biceps tendon can be palpated in the bicipital groove.

A right-angle clamp is now used to retract the LHB tendon from the bicipital groove (Fig. 16.7). The LHB tendon is then cut 2 cm above the muscle-tendon junction and whipstitched with a non-resorbable suture four stitches up and four stiches back (Fig. 16.8). Whipstitches over the musculotendinous junction increase the suture stability.

Next, the humerus is cleared off with a periosteal elevator and/or electrocautery at the distal end of the bicipital groove. A drill bit with soft tissue sleeve is used to create a small monocortical socket (Fig. 16.9). Usually an 8 mm socket can be drilled in men and a 7 mm socket in women for later placement of a same size screw.

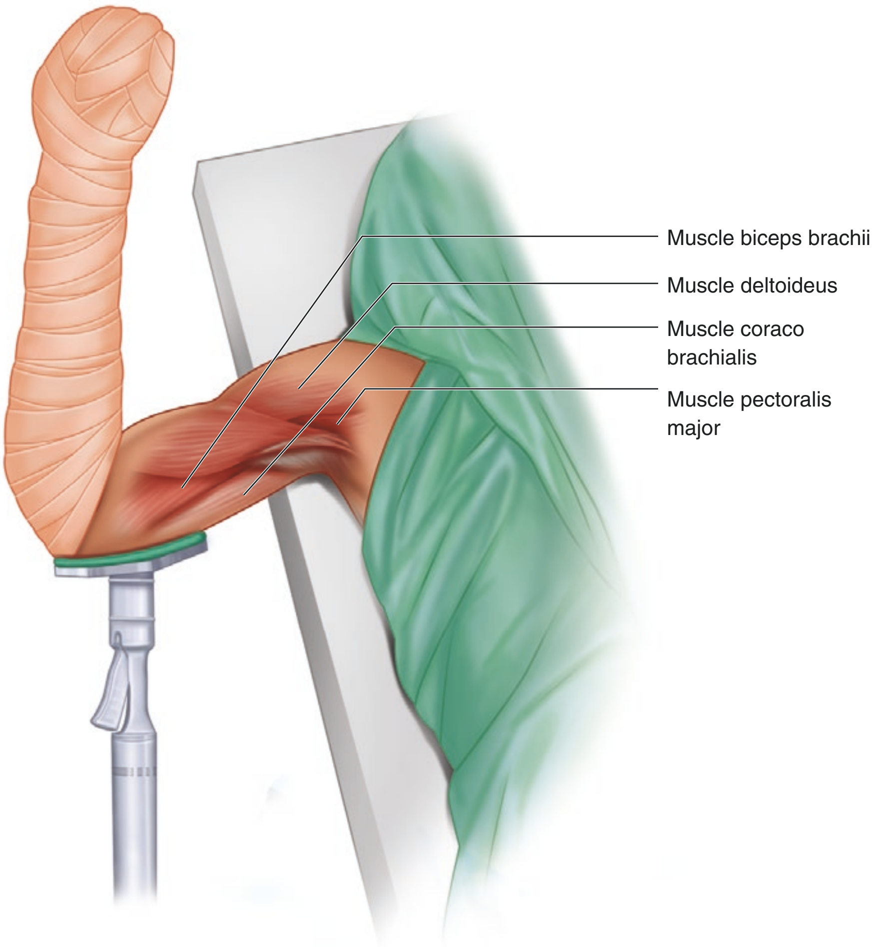


Fig. 16.4 Schematic illustration of the arm position for subpectoral biceps tenodesis. The arm is positioned in a mechanical arm holder in 40–50° of external rotation and 70–80° of abduction. A 2–3 cm incision is made in the axillary crease starting inferior from the crossing point of the above-mentioned lines

Ideally, the drill hole is placed at the center of humerus to avoid weakening of the humeral shaft with subsequent fracture. A guide wire can be placed first to ensure optimal socket positioning. A PEEK interference tenodesis screw is used to fix the tendon in the socket. One suture limb goes through the screw and one on the outside of the screw (Fig. 16.10).

The tip of the custom-made screwdriver helps to avoid deep insertion of the screw in the humeral shaft. Once the screw is placed in the socket and flush with the near cortex, the sutures are tied over the top to lock the sutures in place. The sutures are then cut, and the wound is closed in a layered fashion.

Fig. 16.5 Left shoulder, view from anterior. Incision for subpectoral biceps tenodesis (red arrow), inferior from the crossing point of the axillary crease (black dotted line), and the inferior border of the pectoralis major tendon (yellow line)

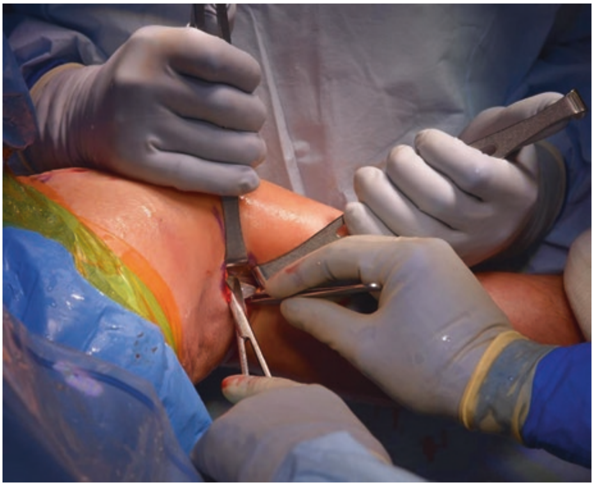


Fig. 16.6 Left shoulder, view from anterior. The pectoralis major tendon is elevated with army-navy retractors, and the fascia layer in the interval between the short head of the biceps and pectoralis major is incised

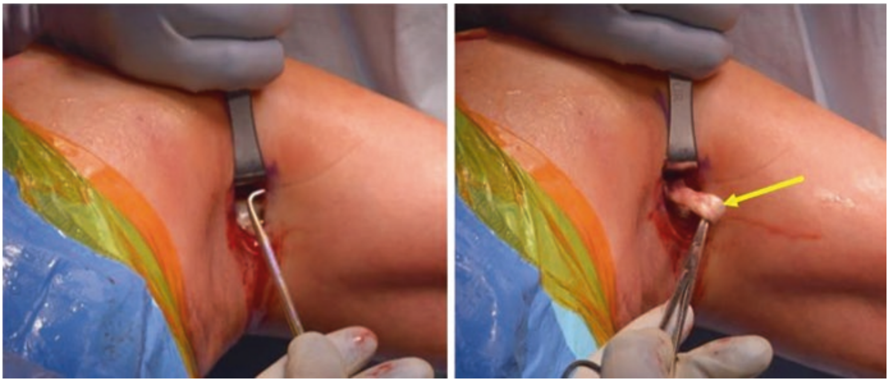


Fig. 16.7 Left shoulder, view from anterior. While the pectoralis major tendon is still elevated with the army-navy retractor, a right-angle clamp is used to retrieve the long head of the biceps tendon (yellow arrow) from the bicipital groove

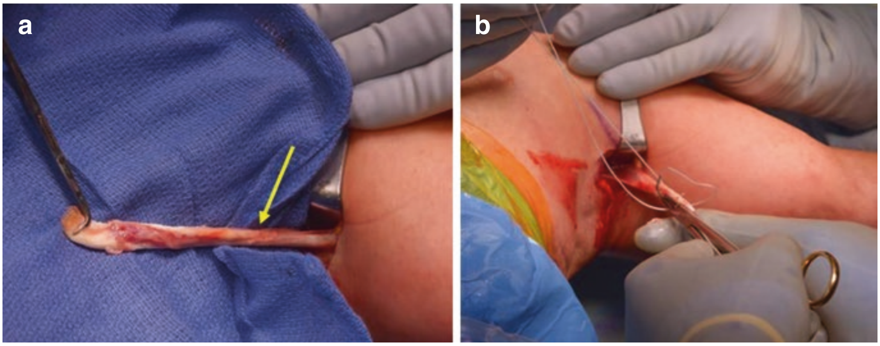


Fig. 16.8 Left shoulder, view from anterior. (**a**) After retrieval from the bicipital groove, the long head of the biceps (LHB) tendon is cut approximately 2 cm above the musculotendinous junction (yellow arrow). (**b**) Then, the LHB is whipstitched with suture wire, four stiches up, four stiches down

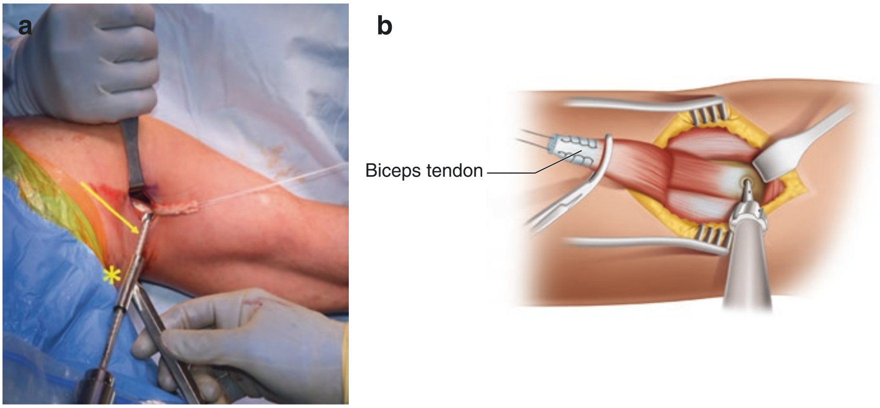


Fig. 16.9 (**a**) Left shoulder, view from anterior: a drill bit (yellow arrow) with soft tissue sleeve (yellow star) is used to create a small monocortical socket. (**b**) Schematic illustration of the drill process which can be facilitated by drilling over a pre-placed K-wire in the center of the humeral shaft to avoid eccentric placement of the screw hole

SLAP Repair

For SLAP lesions type II and types IV–VII (Fig. 16.1), the labrum is repaired with suture anchors back to its origin. Usually two accessory portals are needed: an anterosuperior portal with good trajectory to the anterosuperior glenoid and a lateral trans-rotator cuff portal through the muscular part of the supraspinatus tendon. 5 mm × 7 cm cannulas are placed in the accessory portals. First, the extension of the SLAP lesion is examined with the use of a probe (Fig. 16.11).

In certain cases, using a curved guide allows the anchors for the SLAP repair to be placed through the rotator interval, and then the sutures can be shuttle percutaneously

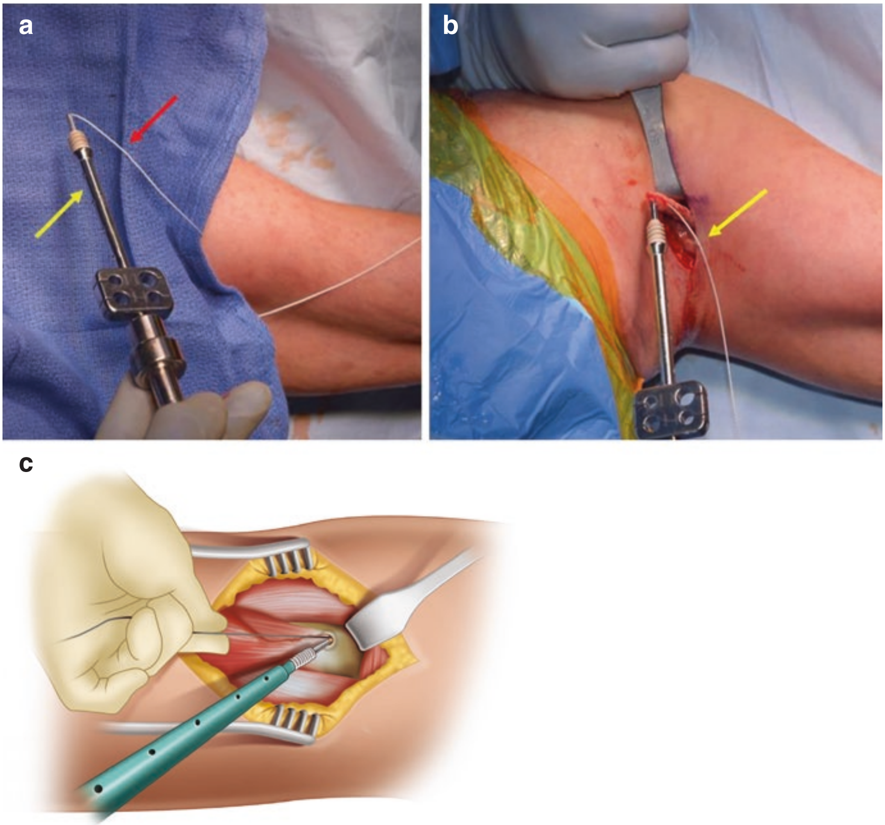


Fig. 16.10 (**a**) A PEEK interference tenodesis screw with a custom-made screwdriver (yellow arrow) is used to fix the tendon in the socket. One suture limb goes through the screw (red arrow) and one on the outside of the screw (**b**, yellow arrow). (**c**) Schematic illustration of the screw placement with the proximal end of the biceps tendon being pushed into the screw hole. While one suture limb goes through the screw, the second limb is passed outside the screw

using #1 PDS suture and a spinal needle. In such cases, the entire SLAP repair therefore can be performed in a manner that obviates the need for a trans-rotator cuff portal, and such an approach is particularly attractive in throwing athletes and those who participate in overhead sports.

Knotless 3.0 mm suture anchors are then placed on the glenoid rim. Depending on the type and extension of the SLAP tear, 3–6 anchors may be needed. In all cases one anchor is placed directly posterior to the biceps origin through the trans-cuff portal and another suture anchor directly anterior to the biceps origin through the anterosuperior portal. For placement of the knotless 3.0 mm suture anchors, the guide is placed through the cannula, and a 2.4 mm drill hole is placed at the insertion site with the use of a 2.4 mm drill. It is important to ensure not to capture the biceps tendon with the drill. The drill should be inserted all the

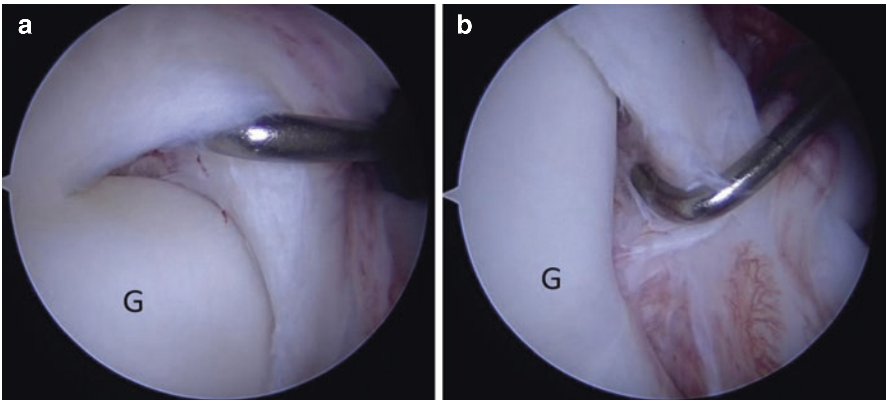
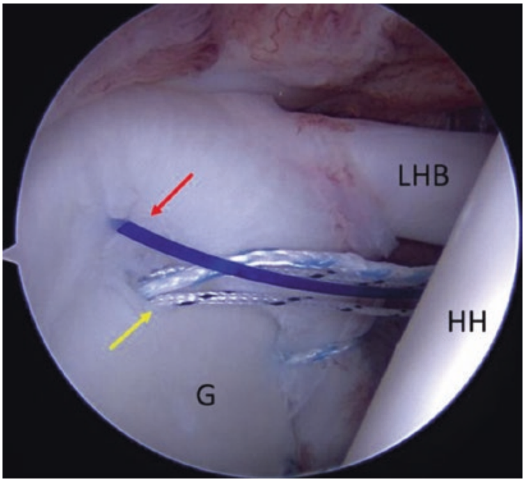


Fig. 16.11 Arthroscopic view of a right shoulder through the posterior portal. SLAP IV lesion with instability of the biceps anchor (**a**) and the anterior labrum (**b**); G, glenoid

Fig. 16.12 Arthroscopic view of a right shoulder through the posterior portal. A lasso shuttle suture (red arrow) is passed beneath the superior labrum coming from medial for passage of the suture wire from the previously placed 3.0 mm suture anchor. LHB long head of the biceps tendon, G glenoid, HH humeral head



way to the hub and moved back and forth a couple of times to ensure that all bone debris is removed from the socket. Next, the 3.0 mm suture anchor is inserted in the drill hole and tapped all the way to the laser mark so that it is flush with the glenoid bone. A crescent lasso is passed through and beneath the labrum coming from medial (Fig. 16.12) and grasped with an alligator grasper through the anterosuperior portal.

The knotless suture anchor is loaded with three wires: one suture and two suture links. First, the suture is passed beneath the labrum with the crescent lasso (Fig. 16.13). Next, the suture and the suture link with the loop on it are retrieved

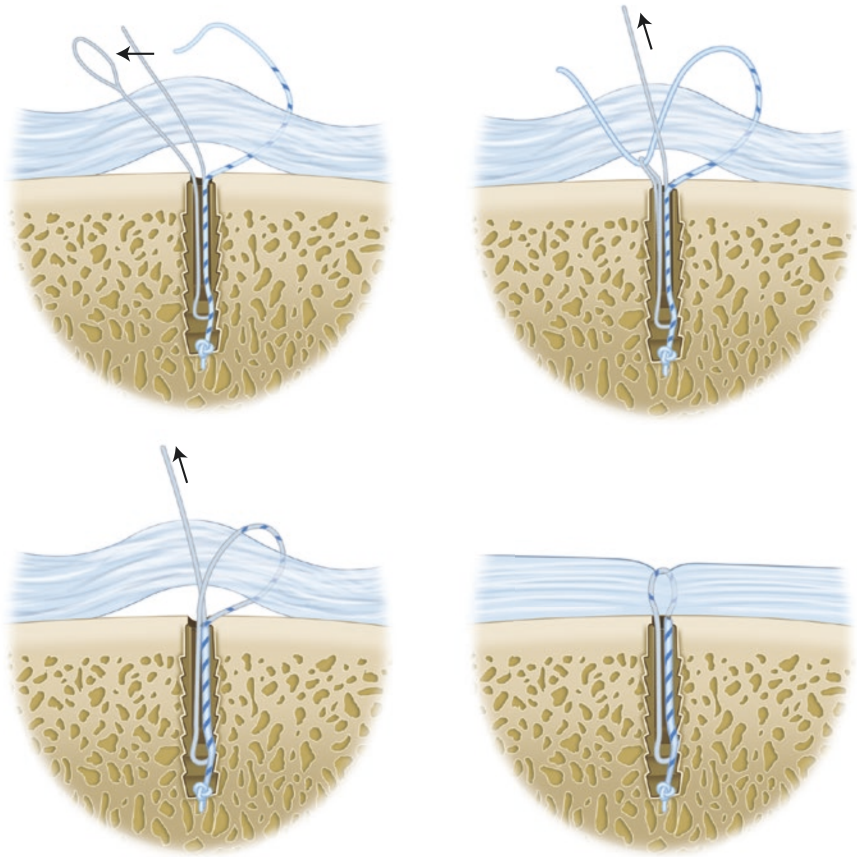


Fig. 16.13 The suture wire and the suture link with the loop on it are retrieved through the anterosuperior portal, and the suture wire is placed in the loop of the suture link. Next, the second suture link is pulled until the suture wire is locked in the 3.0 mm knotless suture anchor. The suture link is removed, and the suture wire is pulled to fix the labrum with good tension to the glenoid rim

through the anterosuperior portal, and the suture wire is placed in the loop of the suture link. Next, the second suture link is pulled until the suture wire is locked in the 3.0 mm knotless suture anchor. The suture link is removed, and the suture wire is pulled to fix the labrum with good tension to the glenoid rim. A guillotine cutter is then used to apply the final tension and to cut the suture wire flush with the anchor.

The knotless fixation of the labrum avoids knot irritation in the glenohumeral joint (Fig. 16.14). In patients with a concomitant tear of the biceps tendon, BRP lesions, or biceps tenosynovitis and in patients with failed prior SLAP repair and in patients older than 35 years, the SLAP repair should be combined with a LHB tenotomy and subpectoral LHB tenodesis with the same surgical technique as described above.

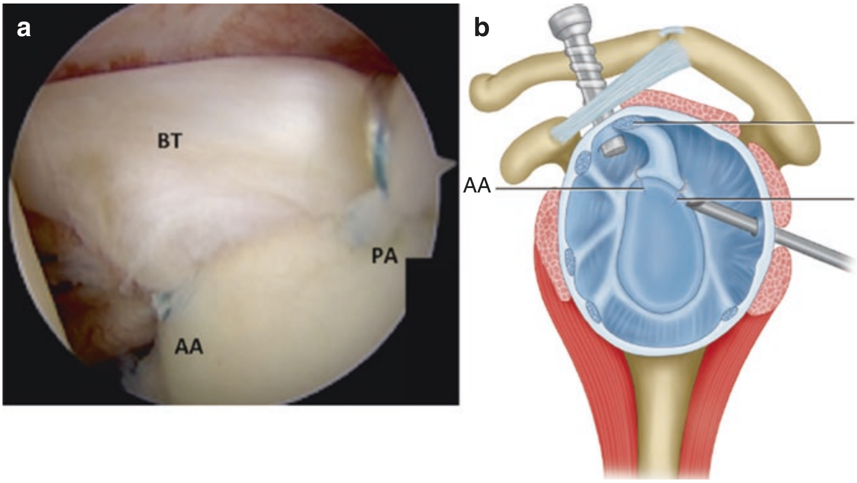


Fig. 16.14 (**a**) Intra-operative picture of a final construct of a knotless SLAP repair. (**b**) Schematic drawing of the postoperative result. The knotless fixation of the labrum avoids knot irritation in the glenohumeral joint. AA anterior anchor, PA posterior anchor, BT biceps tendon

Pearls and Pitfalls

LHB Tenotomy and Subpectoral Tenodesis

Surgical step	Pitfalls	Pearls
Diagnostic arthroscopy	Missing concomitant lesions	Performing a thorough and standardized examination allows for identification of concomitant lesions
Tenotomy of the biceps tendon	Injury to labrum may occur if the tendon is cut too close to the labrum. On the other hand, remaining biceps tissue may impinge in the glenohumeral joint if cut too far from the anchor	Start to cut the biceps from inferior parallel to the glenoid face and the labrum. Finish tenotomy from superior for the last 20% of the tendons thickness
Identification of landmark for subpectoral incision	Localization may not be correct due to soft tissue swelling if the landmarks are identified after arthroscopy	Mark the inferior border of the pectoralis major and the axillary crease with a sterile pen before the start of the surgery
Retrieval of the LHB tendon from the bicipital sulcus	Injury to the musculocutaneous nerve can occur if the long head of the biceps tendon is suspected too far medially	Search for the long head of the biceps tendon (LHB) between the inferior border of the pectoralis major tendon and the lateral border of the short head of the biceps. Usually the LHB can be palpated through the overlaying fascia layer
Shortening and whipstitching of the LHB tendon	The LHB may be too short with too much tension or too long with too little tension	For subpectoral tenodesis the biceps should be cut approximately 2 cm above the musculotendinous junction to achieve the correct physiologic tensioning

Surgical step	Pitfalls	Pearls
Drilling the socket for the tenodesis interference screw	Eccentric drilling can weaken the humerus and lead to humeral shaft fractures	The socket should be placed at the center of the humeral shaft
Insertion of the LHB tendon and the tenodesis interference screw	The tendon may slip out of the socket, and the screw can be inserted too far into the humeral shaft	Use of a tenodesis interference screw with passage of one suture limb through the screw can minimize the risk of tendon slippage. Use of a custom-made screwdriver with depth control can minimize the risk of too deep screw insertion

SLAP Repair

Surgical step	Pitfalls	Pearls
Diagnostic arthroscopy	Missing concomitant lesions	Performing a thorough and standardized examination allows for identification of concomitant lesions
Placement of the anterosuperior working portal	Suboptimal portal placement can impede optimal anchor placement and SLAP repair	Use of a spinal needle to plan the trajectory helps to optimize the portal placement
Placement of the trans-rotator cuff portal	Portal placement through the footprint and the tendinous part of the supraspinatus can lead to a full-thickness supraspinatus tear	The portal should be placed medial from the rotator cable through the muscular part of the supraspinatus to avoid a subsequent tear
Drilling of the sockets for the 3.0 mm SutureTak anchors	If the socket is too short or filled with bone debris, the anchor cannot be inserted far enough	Insert the drill all way to the hub, and move it back and forth a couple of times to remove the bone debris from the socket
Suture passage	The suture can tangle up in the joint and in the cannulas and make knotless fixation impossible	Make sure that the suture run free, and place them in different portals, depending on which suture limbs are needed for each surgical step
Suture tensioning	If the sutures are not tensioned enough, the repair may be too loose	The guillotine cutter should be used to apply the final amount of desired tension

Postoperative Management

Following isolated LHB tenodeses, patients are restricted from performing resisted elbow flexion maneuvers for at least 6 weeks after surgery. When the quality of the LHB tendon was poor, active elbow flexion was restricted for approximately 4 weeks. Overhead strengthening and heavy lifting were also delayed for approximately 3 months. Otherwise, full active and passive range of motion was allowed immediately postoperatively. When concomitant rotator cuff repair was performed, additional rehabilitation was implemented.

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Part V

Sternoclavicular and Acromioclavicular Joint Pathologies

Treatment of Sternoclavicular Joint Arthritis

17

Andrew G. Geeslin, Erik M. Fritz, and Peter J. Millett

Introduction/Background

Sternoclavicular (SC) joint pathology is relatively uncommon and may include either instability or arthritis. Instability of the SC joint is covered in a separate chapter. SC joint arthritis may be secondary to repetitive use or may be post-traumatic in origin, and patients may present with pain, crepitus, and swelling. Nonsurgical treatment can include a trial of activity modification, anti-inflammatory medications, physical therapy, and possible corticosteroid injections. Patients with persistent pain despite appropriate nonsurgical management may benefit from surgical treatment with resection arthroplasty. Treating clinicians must have an awareness of the anatomy of the SC joint and adjacent tissues (Fig. 17.1).

Operative Principles

Complex anatomy, adjacent retrosternal anatomic structures, and the infrequency of injury have led to limited enthusiasm for operative treatment of the SC joint. However, for the correctly indicated patient, surgical treatment of the SC joint is an appropriate procedure when performed by surgeons with experience operating in this anatomic region. Additionally, due to the close proximity

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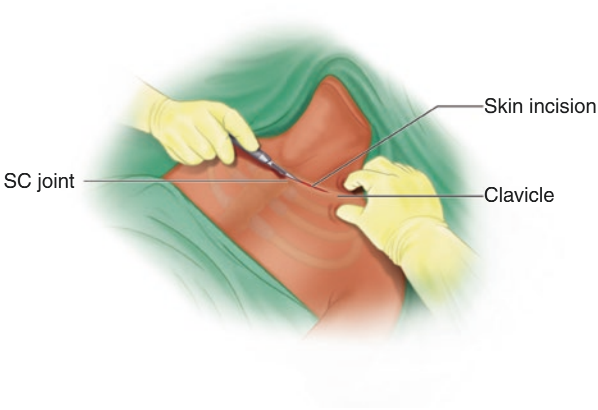


Fig. 17.1 Under general anesthesia, the patient is prepped and draped and placed in 30° of reverse Trendelenburg. The chest is widely prepped to permit a thoracotomy should an intraoperative complication occur

of the retrosternal structures, it is important to have a thoracic surgeon available for assistance if needed. Reconstructive procedures usually include removal of the intra-articular disc, with or without resection arthroplasty in the setting of arthritis, and possible reconstruction with a soft tissue graft.

Indications

Reduction via closed techniques is indicated for acute posterior dislocation of the SC joint; open reduction is reserved for dislocations not reducible via closed techniques. Chronic injuries of the SC joint are treated with conservative measures including activity modification, anti-inflammatory medication, and possible injections; surgical treatment is reserved for those with persistent symptoms despite appropriate nonsurgical management.

In patients with osteoarthritis and without SC joint instability, resection arthroplasty has been successful for achieving pain relief. In patients with instability but normal articular surfaces, ligament reconstruction may be utilized to stabilize the injured SC joint. Some patients may have a component of osteoarthritis and instability; the surgical technique is tailored depending on clinical symptoms, examination, and intraoperative findings.

Contraindications

Asymptomatic degeneration or instability is treated conservatively. Additionally, as with all elective surgery, significant general medical comorbidities including cardiac disease, pulmonary disease, and active infection are contraindications to coracoclavicular ligament reconstruction.

Technique

Preoperative Management

Standard anteroposterior (AP) radiographs should be obtained although, due to the overlapping structures, detailed evaluation of the SC joint is often limited. Serendipity views are obtained at a 40° cephalad angle and allow assessment of anteroposterior translation as well as arthritis. Computed tomography scans of the SC joint are useful for the evaluation of the position of the clavicle as well as assessment of the amount of joint degeneration.

Positioning

General endotracheal anesthesia is administered. The patient is placed supine on a standard table in approximately 30° of reverse Trendelenburg. An assessment of SC joint mobility is performed during the exam under anesthesia. The chest is widely prepped to allow full visualization of both SC joints as well as thoracotomy should an intraoperative complication occur (Fig. 17.1).

Open Approach to the SC Joint

The medial clavicle and jugular notch are palpated, and the planned incision is centered over the medial clavicle and SC joint, approximately 10 cm in length. The skin is incised, and dissection is carried through the platysma, down to the anterior SC joint capsule/ligament. It is critical that the surgeon is familiar with the quantitative anatomy of the SC joint and surrounding structures, and this has been described by Lee et al. Important landmarks include both the sternal and clavicular heads of the sternocleidomastoid (SCM) muscle and the SC joint capsule.

An incision through the anterior capsule allows identification and inspection of the articular surfaces of the SC joint as well as the intra-articular disc. Subperiosteal dissection is performed superiorly and inferiorly, allowing elevation of the sternal head of the SCM and the clavicular head of the pectoralis major; a bone clamp can be used to both elevate and stabilize the medial clavicle during dissection (Fig. 17.2). Next, the sternal facet is exposed although soft tissue elevation should be limited to 1 cm to avoid disruption of the sternal attachment of the SCM (Fig. 17.3).

Resection Arthroplasty

Resection arthroplasty is reserved for patients with primary complaints of arthritis without clinical instability. After circumferential soft tissue elevation, a malleable

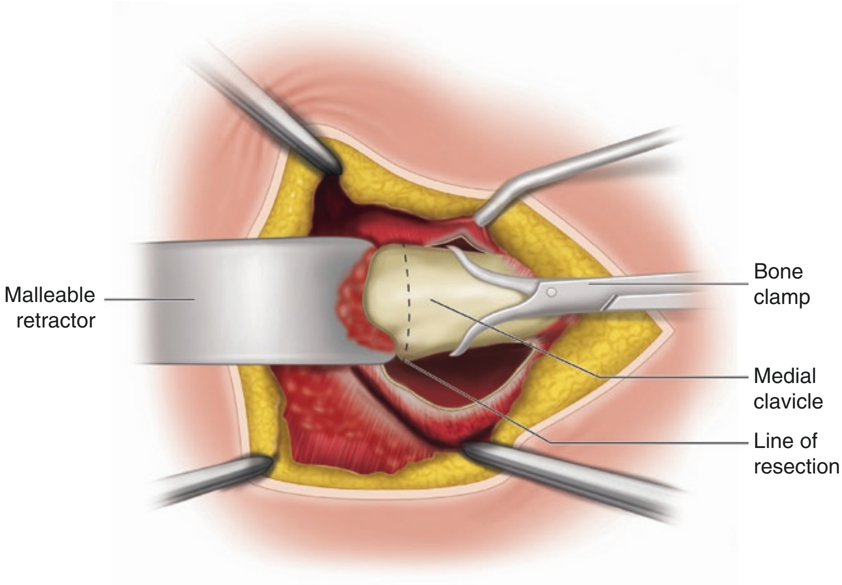
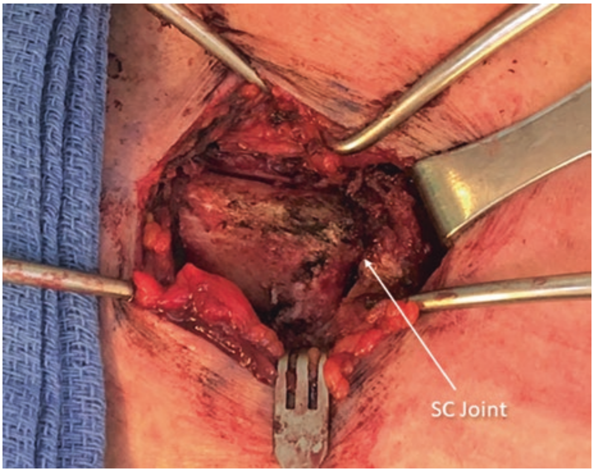


Fig. 17.2 A bone clamp can be used to both elevate and stabilize the medial clavicle during dissection

Fig. 17.3 Next, the sternal facet is exposed although soft tissue elevation should be limited to 1 cm to avoid disruption of sternal attachments



retractor is placed deep to the medial clavicle to protect the mediastinal structures. An oscillating saw is then utilized to resect a maximum of 10 mm of the medial clavicle to preserve the costoclavicular ligament. A rongeur and bone rasp are utilized to contour the medial clavicle to avoid soft tissue irritation, and the intra-articular disc is resected (Fig. 17.4).

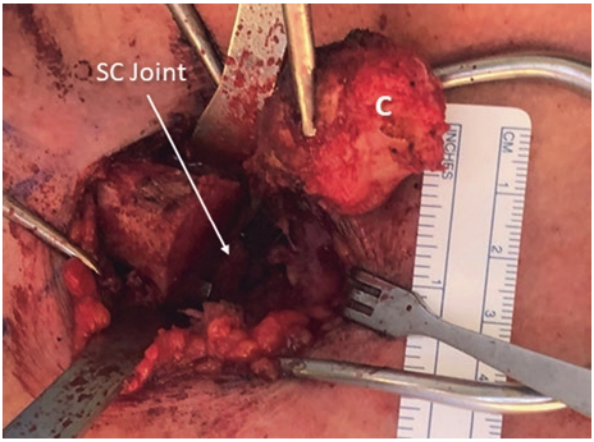


Fig. 17.4 An oscillating saw is then utilized to resect a maximum of 10 mm of the medial clavicle to preserve the costoclavicular ligament. A rongeur and bone rasp are utilized to contour the medial clavicle to avoid soft tissue irritation, and the intra-articular disc is resected. C = resected medial part of the clavicle

Pearls and Pitfalls

Surgical step	Pitfalls	Pearls
Draping	Insufficient exposure	Confirm wide visualization of the chest, bilateral SC joints
Exposure	Inadequate visualization of SC joint	Palpate medial clavicle and jugular notch, 10 cm incision centered over medial clavicle and SC joint
Resection arthroplasty	Inadequate visualization for safe resection	Circumferential soft tissue elevation around SC joint, place malleable retractor deep to SC joint

Postoperative Management

Early passive motion is initiated in the immediate postoperative period. Active and active assisted motion is initiated at approximately 1–2 weeks postoperatively, and a sling may be used for the first 2 weeks for comfort. A gradual return to normal activities is allowed.

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18 Treatment of Sternoclavicular Joint Instability

Andrew G. Geeslin, Erik M. Fritz, and Peter J. Millett

Introduction/Background

Sternoclavicular (SC) joint pathology is relatively uncommon and may include either instability or arthritis. The most common cause of instability is high-energy trauma, and patients may present with anterior or posterior subluxation or dislocation. Additionally, patients may present with pain and symptoms of arthritis that may be post-traumatic or due to repetitive use.

In cases of acute trauma, locked posterior dislocation may result in compression of retrosternal structures and is usually treated with urgent closed reduction. Anterior subluxation/dislocation is generally treated with conservative measures, and long-term symptoms are uncommon. However, persistent pain and instability of the SC joint may result despite appropriate initial management and may require surgical treatment with resection arthroplasty and possible ligamentous reconstruction. Clinicians treating acute and chronic pathology must have an awareness of the anatomy of the SC joint and adjacent tissues.

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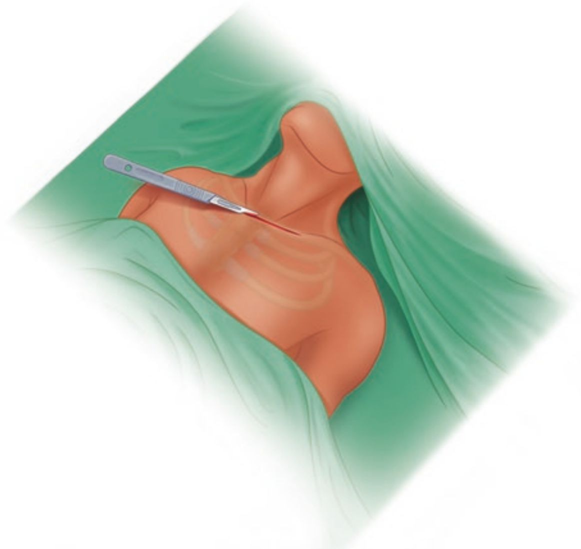

Fig. 18.1 An incision approximately 10 cm in length is made, centered over the medial clavicle and SC joint. The chest is widely prepped to permit a thoracotomy should an intraoperative complication occur

Operative Principles

Complex anatomy (Fig. 18.1), adjacent retrosternal anatomic structures, and the infrequency of injury have led to limited enthusiasm for operative treatment of the SC joint. However, for the correctly indicated patient, surgical treatment of the SC joint is an appropriate procedure when performed by surgeons with experience operating in this anatomic region. Additionally, due to the close proximity of the retrosternal structures, it is important to have a thoracic surgeon available for assistance if needed. Reconstructive procedures usually include removal of the intra-articular disc, with or without resection arthroplasty in the setting of arthritis, and possible reconstruction with a soft tissue graft.

Indications

Reduction via closed techniques is indicated for acute posterior dislocation of the SC joint; open reduction is reserved for dislocations not reducible via closed techniques. Chronic injuries of the SC joint are treated with conservative measures including activity modification, anti-inflammatory medication, and possible injections; surgical treatment is reserved for those with persistent symptoms despite appropriate nonsurgical management.

In patients with osteoarthritis and without SC joint instability, resection arthroplasty has been successful for achieving pain relief. In patients with instability but normal articular surfaces, ligament reconstruction may be utilized to stabilize the injured SC joint. Some patients may have a component of osteoarthritis and instability; the surgical technique is tailored depending on clinical symptoms, examination, and intraoperative findings.

Contraindications

Asymptomatic degeneration or instability is treated conservatively. Additionally, as with all elective surgery, significant general medical comorbidities including cardiac disease, pulmonary disease, and active infection are contraindications to coracoclavicular ligament reconstruction.

Technique

Preoperative Management: Clinical Examination and Imaging

Appropriate radiographs are important for the initial evaluation of the SC joint. Because acute SC joint injuries are usually due to high-energy trauma, it is important to also obtain imaging of adjacent joints if clinically indicated. Standard anteroposterior (AP) radiographs should be obtained although, due to the overlapping structures, detailed evaluation of the SC joint is often limited. Serendipity views are obtained at a 40 degree cephalad angle and allow assessment of anteroposterior translation as well as arthritis. Computed tomography scans of the SC joint are useful for the evaluation of the position of the clavicle as well as assessment of the amount of joint degeneration.

Positioning

General endotracheal anesthesia is administered. The patient is placed supine on a standard table in approximately 30° of reverse Trendelenburg. An assessment of SC joint laxity is performed during the exam under anesthesia. The chest is widely prepped to allow full visualization of both SC joints as well as adequate exposure for a thoracotomy should an intraoperative complication occur. In patients with a planned SC joint reconstruction, the ipsilateral leg is prepped and draped to allow autogenous hamstring tendon harvest.

Open Approach to the SC Joint

The medial clavicle and jugular notch are palpated, and the planned incision is centered over the medial clavicle and SC joint, approximately 10 cm in length (Fig. 18.1). The skin is incised, and dissection is carried through the platysma, down to the anterior SC joint capsule/ligament (Fig. 18.2). It is critical that the surgeon is familiar with the quantitative anatomy of the SC joint and surrounding structures, and this has been

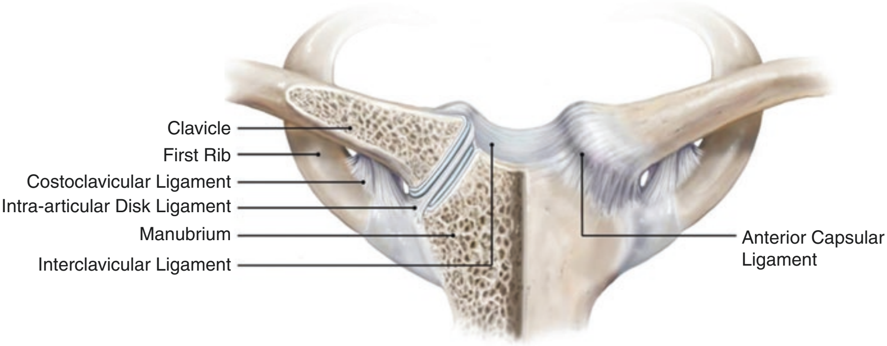

Fig. 18.2 Osseoligamentous anatomy of the sternoclavicular joint. (Reprinted from Martetschläger et al. [1])

described by Lee et al. Important landmarks include both the sternal and clavicular heads of the sternocleidomastoid (SCM) muscle, the SC joint capsule.

An incision through the anterior capsule allows identification and inspection of the articular surfaces of the SC joint as well as the intra-articular disc. Subperiosteal dissection is performed superiorly and inferiorly, allowing elevation of the sternal head of the SCM and the clavicular head of the pectoralis major; a bone clamp can be used to both elevate and stabilize the medial clavicle during dissection (Fig. 18.3). Next, the sternal facet is exposed although soft tissue elevation should be limited to 1 cm to avoid disruption of the sternal attachment of the SCM.

SC Joint Reconstruction

Reconstruction of the SC joint with a gracilis graft and bone tunnels is considered in patients with clinical instability and objective laxity. Graft harvest and preparation are completed, followed by tunnel preparation and graft passage. An illustration of sequential steps is provided (Fig. 18.3).

Gracilis Tendon Harvest and Graft Preparation

Autograft tissue is preferred for reconstruction of the SC joint although allograft is an option. Gracilis tendon harvest is performed from the ipsilateral leg in a similar fashion to that performed for hamstring tendon harvest for anterior cruciate ligament reconstruction, and the anatomy and surgical approach are well-described. The ends of the gracilis tendon then are whipstitched to enable later graft passage and fixation.

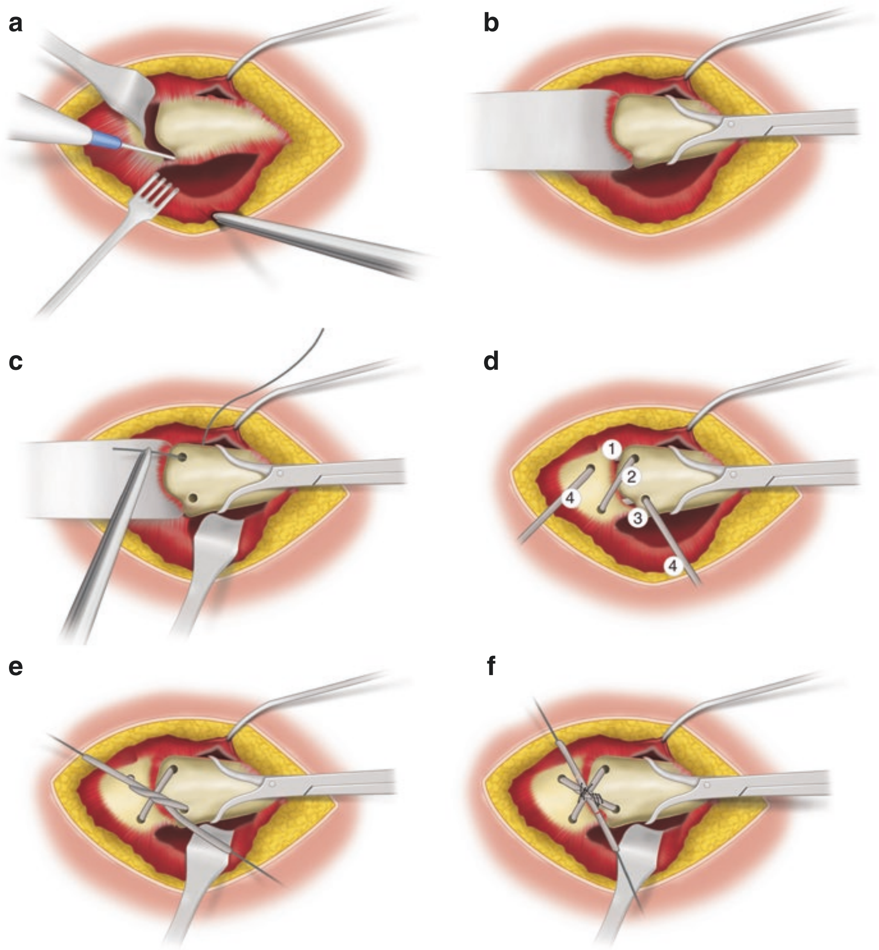

Fig. 18.3 Surgical steps for sternoclavicular reconstruction are shown. (**a**) Subperiosteal dissection is performed superiorly and inferiorly. (**b**) A bone clamp can be used to both elevate and stabilize the medial clavicle during dissection. (**c**) A malleable retractor is placed deep to the medial clavicle during creation of the two clavicular bone tunnels. (**d**) The graft is shuttled through the clavicular and sternal tunnels with two horizontal limbs posteriorly. (**e**) The free limbs of the graft are tied with an overhand knot. (**f**) Multiple nonabsorbable sutures are placed through the crossing limbs for fixation of the graft

Tunnel Preparation

The surgeon may complete tunnel preparation while the previously harvested gracilis graft is prepared on the back table. Circumferential elevation of the medial clavicle is performed, and a malleable retractor is placed to protect the deep structures (Fig. 18.4). A guide pin is placed bicortically through the medial clavicle, aimed at

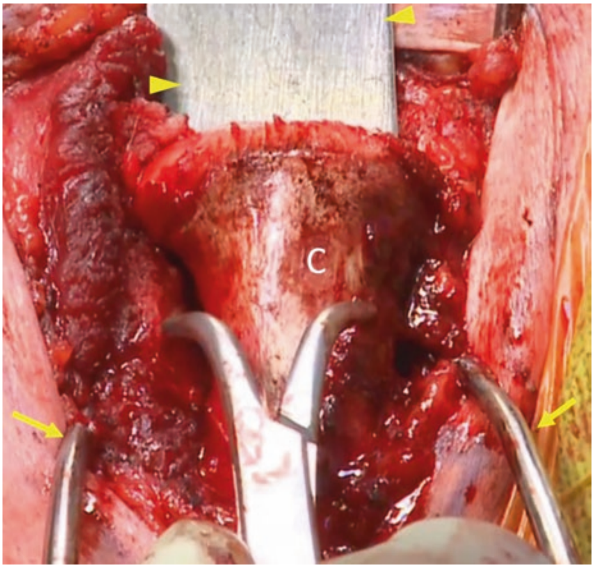

Fig. 18.4 View following the approach to a left-sided sternoclavicular joint. A bone clamp (arrows) is used to both elevate and stabilize the medial clavicle (C) during dissection. A malleable retractor (arrowheads) is placed deep to the medial clavicle to protect the mediastinal structures

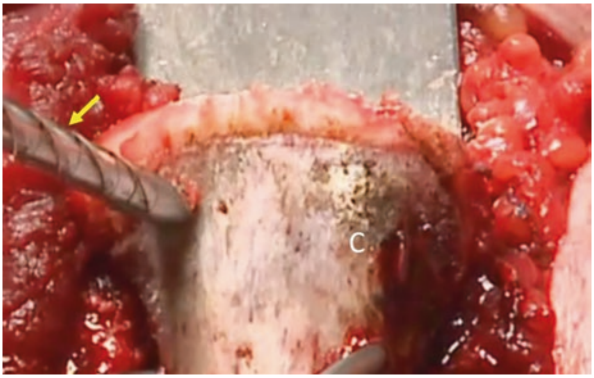

Fig. 18.5 View following the approach to a left-sided sternoclavicular joint. A 4 mm reamer (arrow) is run over a guide pin to expand the tunnel for subsequent graft placement. C clavicle

the malleable retractor, and positioned in the inferior third and approximately 1 cm lateral to the joint. It is then expanded with a reamer, typically 4 mm in diameter, guided by patient size (Fig. 18.5). An additional tunnel is placed in the superior third, spaced evenly from the first tunnel, and similarly reamed. A passing suture is placed through each tunnel for later graft passage (Fig. 18.6).

Tunnel creation within the sternum is then performed. Similarly, subperiosteal soft tissue elevation is performed, and a malleable retractor is placed deep to the manubrium (Fig. 18.7). Two tunnels are then created, approximately 1 cm medial to the SC joint articular surface, spaced 1.5 cm, and passing sutures are placed (Fig. 18.8).

Graft passage is next performed following tunnel creation and graft preparation. Any of the four tunnels may be utilized to initiate graft shuttling. Our preferred

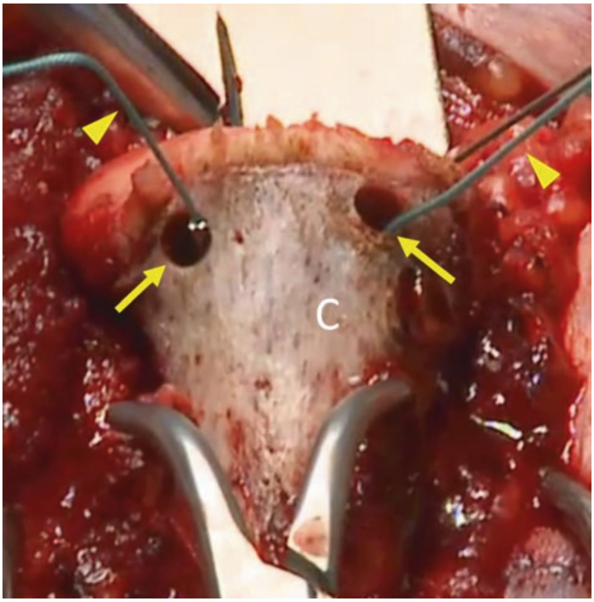

Fig. 18.6 View following the approach to a left-sided sternoclavicular joint. Following creation of the bone tunnels (arrows), a passing suture (arrowheads) is placed through each tunnel for later graft passage. C clavicle

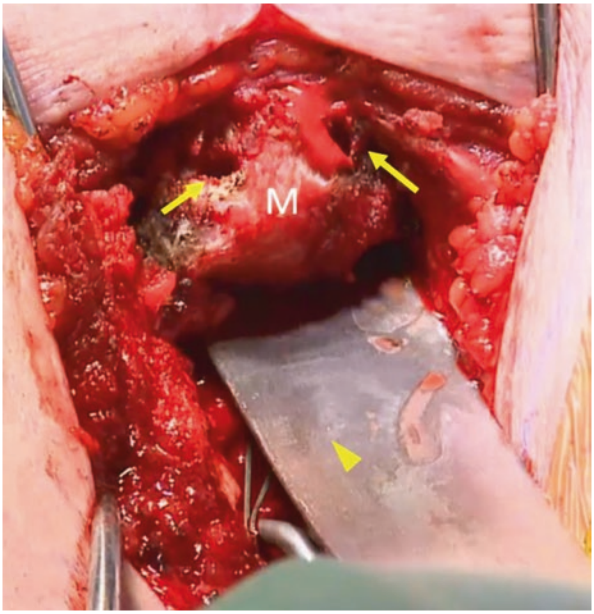

Fig. 18.7 View following the approach to a left-sided sternoclavicular joint. A subperiosteal soft tissue elevation has been performed and a malleable (arrowhead) retractor is placed deep to the manubrium (M) to protect the retrosternal structures. Following this step, the bone tunnels (arrows) are drilled 1 cm medial to the sternoclavicular joint articular surface and spaced 1.5 cm apart

pattern places two posterior transverse parallel limbs and crossing limbs anteriorly (Fig. 18.9). With the joint held reduced, the anterior limbs are tied with an overhand knot and the assistant maintains longitudinal traction on the graft limbs. Several knots using high-strength nonabsorbable suture are then placed through the crossing

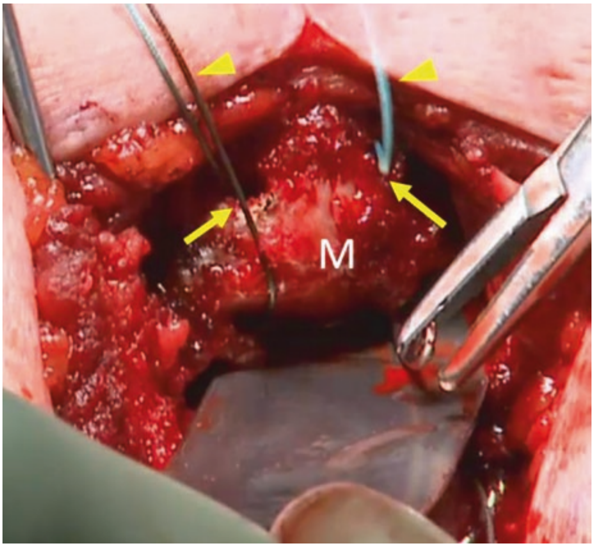

Fig. 18.8 View following the approach to a left-sided sternoclavicular joint. Following creation of the bone tunnels (arrows), a passing suture (arrowheads) is placed through each tunnel for later graft passage. M manubrium

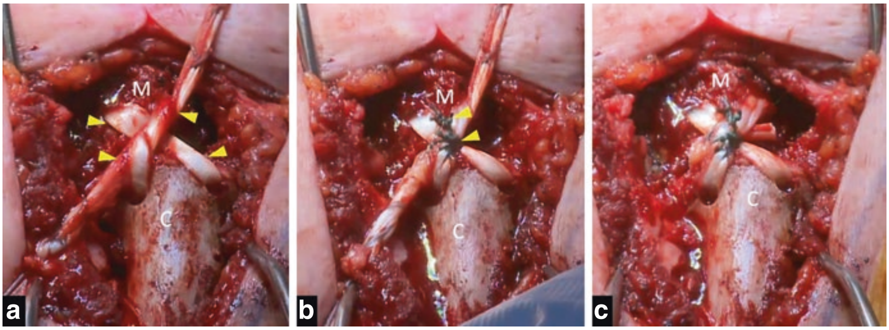

Fig. 18.9 View following the approach to a left-sided sternoclavicular joint. (**a**) The graft (arrowheads) has been passed through the bone tunnels with two posterior transverse parallel limbs and two anterior crossing limbs with the anterior limbs tied using an overhand knot. (**b**) Several knots using high-strength nonabsorbable suture (arrowheads) are then placed through the crossing graft limbs to secure the final construct. (**c**) Residual tissue length on the graft limbs is then sharply removed to complete the final construct. C clavicle, M manubrium

graft limbs to secure the final construct. Residual tissue length on the graft limbs is then sharply removed, and a dynamic examination is performed to ensure joint stability during shoulder range of motion.

Postoperative Management

During the first 6 weeks postoperatively, the shoulder is immobilized with a sling, and scapular protraction/retraction is avoided. Pendulum and passive range-of-motion exercises are initiated in formal physical therapy. Active-assisted range of motion is initiated after 6 weeks followed by a strengthening program after 8 weeks. Return to full activities is delayed until approximately 6 months.

Recommended Literature

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19 Treatment of Acromioclavicular Joint Arthritis

Andrew G. Geeslin, Erik M. Fritz, and Peter J. Millett

Introduction/Background

Acromioclavicular joint (ACJ) pathology is relatively common and may include either instability or arthritis. Instability of the ACJ is covered in a separate chapter. ACJ arthritis may be secondary to repetitive use as seen in distal clavicular osteolysis, may be post-traumatic, or may be a part of normal aging. Patients may present with pain, crepitus, swelling, and prominence of the joint. Nonsurgical treatment can include a trial of activity modification, anti-inflammatory medications, physical therapy, and possible corticosteroid injections. Patients with persistent pain despite appropriate nonsurgical management may benefit from surgical treatment with distal clavicle resection, which may be combined with associated arthroscopic shoulder procedures including subacromial decompression and rotator cuff repair.

Operative Principles

Most arthroscopic shoulder surgeons are familiar with the anatomy of the acromioclavicular joint (Fig. 19.1). The ACJ is accessible via the subacromial space and can be addressed with the patient in the lateral or beach chair position. Several techniques have been described for arthroscopic distal clavicle resection. A distal

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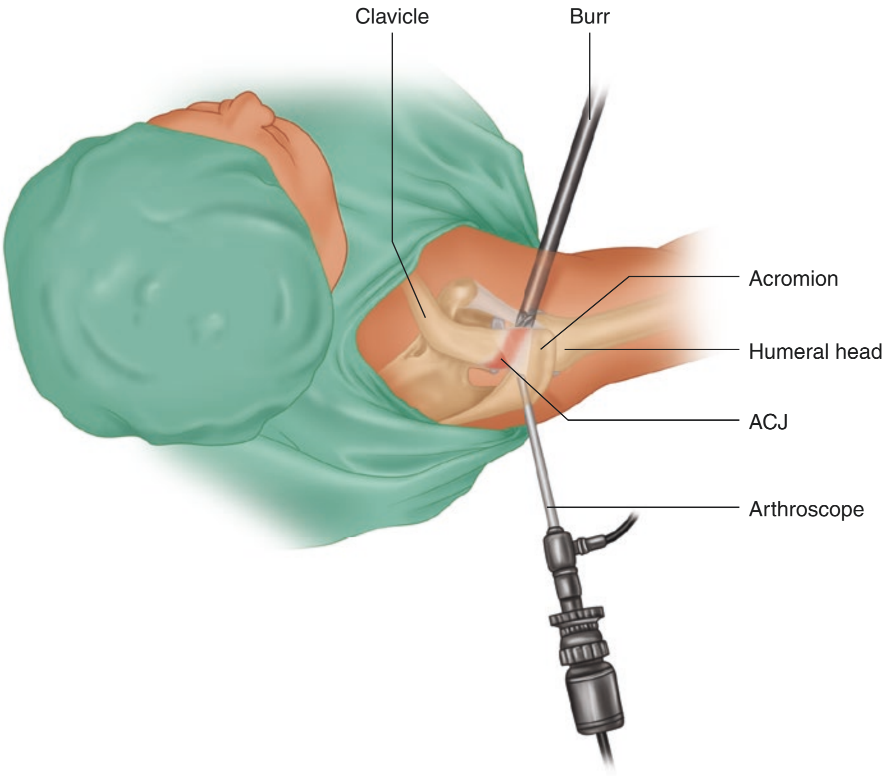

Fig. 19.1 The superior shoulder anatomy including the acromioclavicular joint is shown. The arthroscope is placed in the posterior or lateral portal, and a bur is shown through the anterior portal for distal clavicle resection in chronic cases

clavicle resection of 1 cm is often used as a guideline; under-resection may lead to persistent symptoms, whereas over-resection may lead to instability and pain.

Indications

While arthritis of the ACJ is commonly identified radiographically, it is often not clinically symptomatic. Point tenderness over the acromioclavicular joint as well as localized pain with cross-body adduction may be used to determine whether the ACJ is a cause of symptoms. Resolution of pain following an intra-articular ACJ injection is also suggestive of pain due to an arthritic ACJ. Nonsurgical treatment can include activity modification, anti-inflammatory medication, and intra-articular corticosteroid injection. Surgical treatment via arthroscopic resection of the distal clavicle can be considered in patients with localized pain at the ACJ and persistent symptoms despite nonsurgical management. This chapter reviews our recommended evaluation as well as our preferred technique for surgical treatment of symptomatic ACJ arthritis.

Contraindications

Asymptomatic ACJ arthritis is treated conservatively. Additionally, as with all elective surgery, significant general medical comorbidities including cardiac disease, pulmonary disease, and active infection are contraindications to distal clavicle resection.

Technique

Preoperative Management

Standard radiographs including anteroposterior, axillary, and Zanca views allow characterization of the ACJ. Magnetic resonance imaging allows a comprehensive assessment of the ACJ including joint morphology, presence of cysts, and capsular hypertrophy.

Technique

Preoperative Preparation

A regional interscalene block is placed by the anesthesiologist, and general anesthesia is induced. The patient is placed in the modified beach chair position, and a pneumatic arm holder is utilized. The operative shoulder is widely prepared and draped under sterile conditions.

Diagnostic Arthroscopy

After ensuring correct positioning and draping, a standard posterior portal is created, followed by establishment of an anterosuperior portal through the rotator interval using direct visualization. Intra-articular assessment is performed as indicated, and associated pathology is addressed. Following completion of intra-articular procedures, the subacromial space is entered. One or two lateral portals are created, depending on concomitant procedures. A complete bursectomy is performed, and an acromioplasty is performed in patients with an acromial spur; this will also improve visualization for the distal clavicle resection.

The inferior capsule is debrided with the radiofrequency cautery, and hemostasis is obtained. A switching stick is utilized, and the anterior portal is re-established in line with the ACJ; a cannula may be inserted over a dilator. The anterior ACJ capsule is then debrided with the radiofrequency cautery, allowing exposure of the joint; care is taken to preserve the posterior-superior capsule in order to prevent postoperative ACJ instability. Using a systematic approach, a distal clavicle resection is performed, starting anteroinferior, extending superior, and then completing the posterior resection (Chap. 17, Illustration 1). Adequate resection can be confirmed by inserting a bur or cannula of a known size within the ACJ (Fig. 19.2).

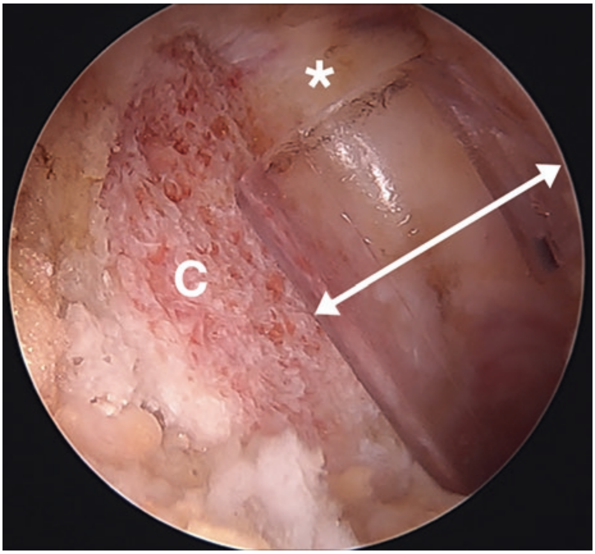

Fig. 19.2 An arthroscopic photograph of a right shoulder ACJ is shown, viewing via the posterior portal from the inferior aspect with a 30 degree arthroscope. A distal clavicle resection is demonstrated with preservation of the superior ACJ capsule. Insertion of the arthroscopic cannula verifies adequate resection. C, clavicle; asterisk, superior capsule; double arrow, cannula within joint

Pearls and Pitfalls

Surgical step	Pitfalls	Pearls
Exposure	Inadequate visualization of AC joint	The radiofrequency cautery should be used to expose anteriorly and inferiorly
Posterior ACJ access	Inadequate anterior resection	Ensure complete anterior resection from inferior to superior to ensure that the bur is able to access the posterior aspect of the joint
Posterior-superior distal clavicle resection	Incomplete resection	Ensure adequate visualization and capsular release to complete resection of the posterior-superior corner of the ACJ
Completion of distal clavicle resection	Over- or under-resection	Use the bur or a cannula as a guide to monitor the amount of resection; a 70 degree arthroscope may be beneficial

Postoperative Management

Early passive motion is initiated in the immediate postoperative period. Active and active assisted motion is dictated primarily by concomitant procedures (e.g., rotator cuff repair, biceps tenodesis). A sling may be used for the first 2 weeks for comfort. A gradual return to normal activities is allowed.

Recommended Literature

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Treatment of Acromioclavicular Joint Separation

20

Andrew G. Geeslin, Erik M. Fritz, and Peter J. Millett

Introduction/Background

Acromioclavicular (AC) joint injuries are common in contact athletes and after falls onto the acromion. The Rockwood classification system is commonly used to describe injury severity including direction and degree of displacement. Grade I and II injuries affect only the AC joint without disruption of the coracoclavicular (CC) ligaments, whereas grades III–VI are associated with disruption of the AC joint and CC ligaments and are associated with greater displacement (Fig. 20.1).

Grade I and II injuries are treated conservatively, whereas high-grade injuries may benefit from surgical management. Most surgeons agree that surgical treatment of grades IV–VI results in optimal outcomes. However, there is currently debate regarding the optimal treatment for grade III injuries, although many surgeons recommend surgical treatment for high-level athletes and laborers.

Recently, Beiztel et al. proposed a modification to the classic Rockwood classification in which grade III injuries may be further subdivided into IIIA and IIIB; grade IIIA injuries are stable and may respond well to conservative management, but grade IIIB injuries are unstable and should be treated surgically.

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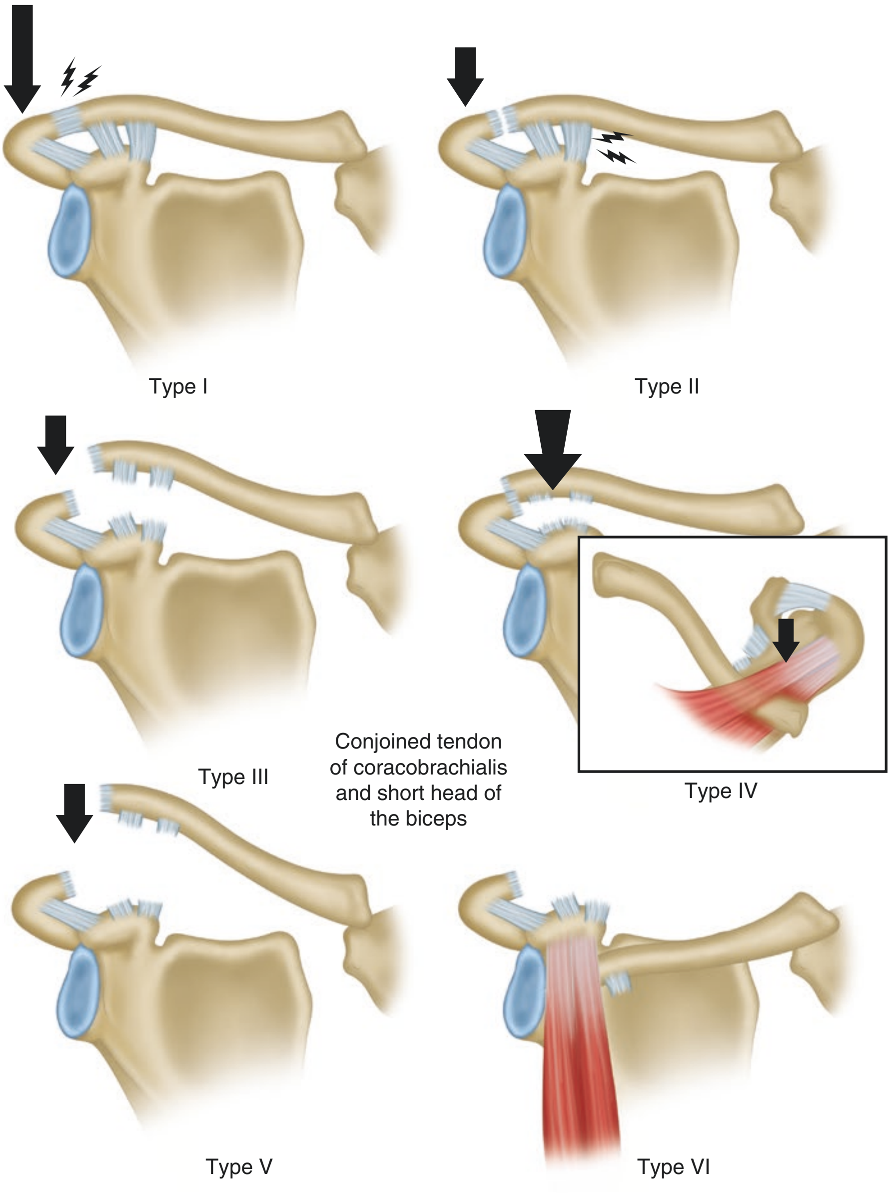

Fig. 20.1 Rockwood's classification of acromioclavicular separations Types I to VI is shown. A Type I injury is a mild sprain of the AC ligament, Type II is a ruptured AC capsule and sprained CC ligaments, Type III is a superior dislocation of the AC joint with ruptured AC capsule, CC ligament, Type IV is a posterior dislocation of the AC joint with ruptured AC capsule, CC ligament, Type V is a gross superior dislocation of the AC joint with ruptured AC capsule, CC ligament, and Type VI is an inferior dislocation of the AC joint with rupture of the AC ligament, CC ligament, and joint capsule. (Reprinted with permission from Lasanianos NG, Panteli M. Acromioclavicular (AC) joint dislocation. In: Lasanianos NG, Kanakaris NK, Giannoudis PV, eds. Trauma and Orthopaedic Classifications. London, UK: Springer-Verlag London; 2015:3-6.)

Operative Principles

Historically, surgical treatment was complicated by loss of reduction due to inadequate soft tissue reconstruction procedures or failure of fixation. However, advanced techniques have improved biomechanical performance. By reducing the clavicle using high-strength suture and cortical buttons with or without soft tissue grafts, the alignment of the AC joint is restored. This chapter will describe our preferred CC ligament reconstruction technique including a preoperative checklist, a detailed description of the procedure, an overview of postoperative management, as well as critical steps to optimize results.

Preoperative Checklist

Appropriate radiographs are crucial for the evaluation of a patient with an AC joint injury. Radiographs of the affected shoulder should include AP, axillary, and Zanca views. Consideration for surgical reconstruction is based on interpretation of these radiographs along with a thorough history and physical examination.

Our preferred surgical technique includes an arthroscopic evaluation as it has been reported that concomitant intra-articular pathologies occur in up to 30% of patients with AC joint injuries. Standard arthroscopic and open instrumentation is required, along with specific instruments unique to the CC ligament reconstruction procedure (Table 20.1).

A regional interscalene block is placed by the anesthesiologist, and general anesthesia is induced. The patient is placed in the modified beach chair position, and a pneumatic arm holder is utilized (Fig. 20.2). The operative shoulder is widely prepared and draped under sterile conditions. Fluoroscopy is utilized intraoperatively, and appropriate visualization must be confirmed prior to initiation of the procedure (Fig. 20.3).

Procedure in Detail

After ensuring correct positioning and draping, and availability of required instruments (Table 20.1), a surgical pause is performed. Then, a standard posterior portal is created, followed by establishment of an anterosuperior portal

Table 20.1 Recommended surgical instruments and implants for coracoclavicular ligament reconstruction

Arthroscopic instruments	Open surgical instruments	Implants
Arthroscopic camera, (30°, 70° arthroscopes) Fluid management system Radiofrequency ablation probe Arthroscopic shaver and burr Probe Cannulas Cannula dilator	Electrocautery Subperiosteal elevators Drill guide 2.4-mm cannulated drill 8.25-mm cannula dilator	Suture tape (4 strands) Cortical buttons (2) Soft tissue graft (8 mm diameter)

through the rotator interval using direct visualization. An accessory anteroinferior portal is also created through the rotator interval to allow access to the subcoracoid space (Fig. 20.4).

After identification and treatment of intra-articular pathology, the coracoid is identified, and the inferior aspect is debrided using radiofrequency ablation and

Fig. 20.2 Right arm prepped and draped in the beach chair position with a pneumatic arm holder. Intraoperative fluoroscopy is sterilely draped into the surgical field

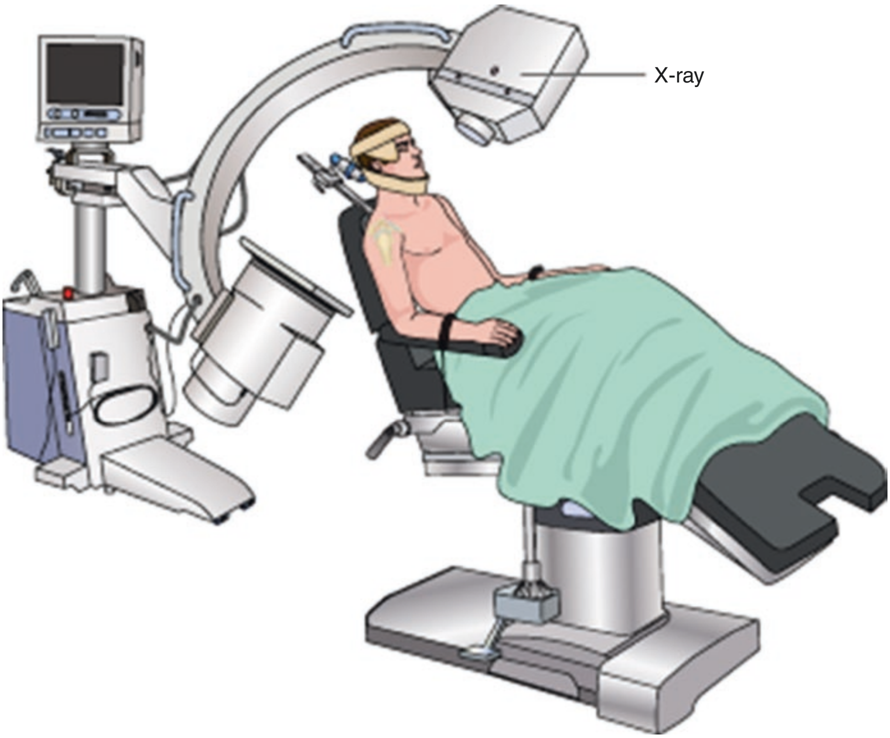

Fig. 20.3 Intraoperative positioning, including a pneumatic arm holder and fluoroscopy, is shown. It is important to assess positioning prior to sterile prep and draping to ensure adequate visualization on imaging

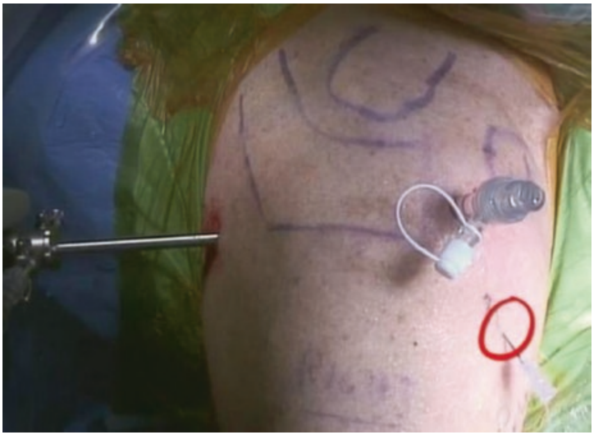

Fig. 20.4 Spinal needle localization for creation of anteroinferior portal placed in a right shoulder

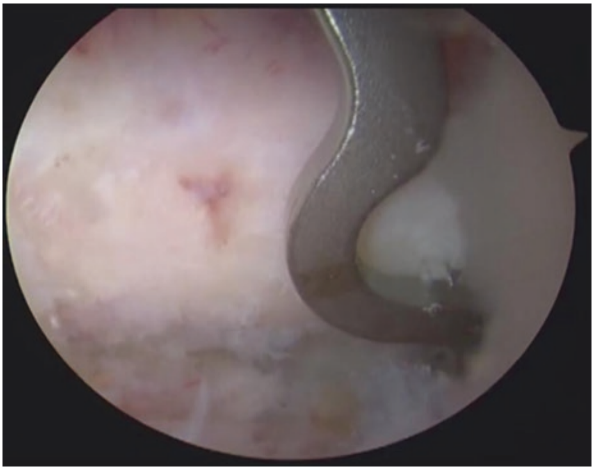

Fig. 20.5 Arthroscopic view through the standard posterior portal of the inferior aspect of the coracoid process in a right shoulder. The drill guide is being placed under direct arthroscopic visualization

visualized with a 70° arthroscope placed through the posterior portal (Fig. 20.5). The undersurface of the coracoid is then gently abraded in order to optimize the bone-graft interface for improved healing.

The anatomy of the distal clavicle and coracoid, including the conoid and trapezoid tubercles and insertion sites for the coracoclavicular ligaments, have been described in detail by Rios et al. (Fig. 20.6). Using known landmarks, a 2.5 cm incision is made perpendicular to the long axis of the distal clavicle, approximately 3.5 cm medial to the AC joint. The deltotrapezial fascia is incised along the long

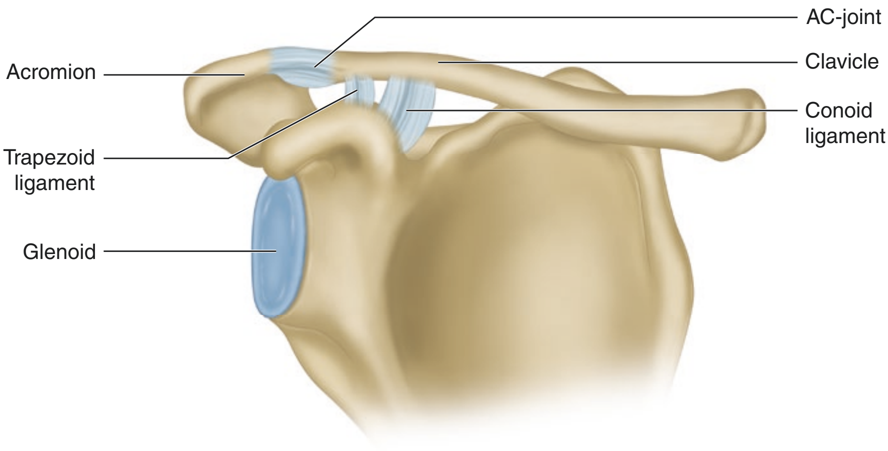

Fig. 20.6 Key bony anatomy and stabilizing structures are shown including the ACJ capsule/ligaments and coracoclavicular (conoid and trapezoid) ligaments

axis of the clavicle and elevated subperiosteally in order to allow robust repair following the procedure. AC joint capsular imbrication or reconstruction with the remaining soft tissue graft may be performed in select cases with substantial laxity. In the setting of post-traumatic AC joint osteoarthritis or an irreducible AC joint, a distal clavicle excision is performed concurrently.

Due to historical reports of postoperative loss of reduction, our preferred technique is a hybrid reconstruction, utilizing a soft tissue graft along with a construct of high-strength suture and a low-profile knotless fixation device. A 3.0-mm tunnel is created centrally through the distal clavicle at the level of the conoid tubercle. Using a drill guide (Fig. 20.5) centered medial to lateral at the posterior aspect of the coracoid base (inserted through the anteroinferior portal), the 3.0-mm cannulated drill is advanced through the clavicle and coracoid under direct arthroscopic visualization to create two in-line tunnels (Fig. 20.7). During this step, great care must be taken to ensure the drill enters the superocentral portion of the clavicle and exits the posteroinferocentral aspect of the coracoid; if drilled incorrectly, the patient will have a higher chance of postoperative clavicular or coracoid fracture. The position of the cannulated drill is verified using intraoperative fluoroscopy (Fig. 20.8).

A 5.0-mm unicortical reamer is then used to create a small socket in the superior aspect of the clavicle; this will ultimately allow the superior clavicle fixation device to sit flush within the bone, thus minimizing soft tissue irritation to the patient.

The central trocar of the 3.0-mm cannulated drill is removed, and a passing stitch is placed. Four strands of suture are shuttled through the tunnels and retrieved out

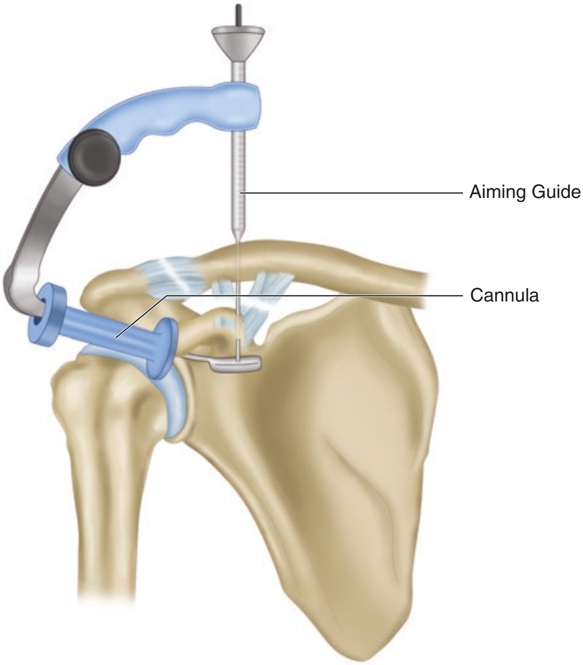

Fig. 20.7 An aiming guide is positioned with the capture device inferior to the coracoid (via an anterior cannula) and the drill sheath superior to the clavicle. The drill is advanced across the clavicle and coracoid as shown

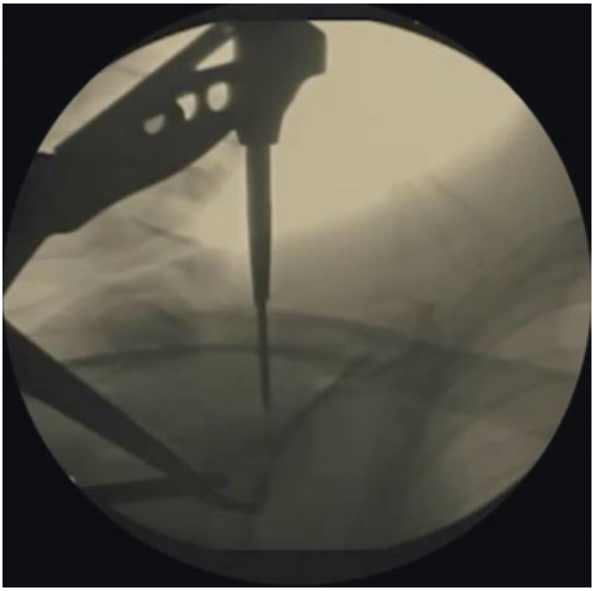

Fig. 20.8 Intraoperative fluoroscopic verification of drill position in the right shoulder

the anteroinferior portal; a cortical button is then loaded onto the sutures and placed at the inferior coracoid.

An 8-mm-diameter soft tissue graft is then prepared using either allograft or autograft. Our preferred graft is an 8-mm (doubled diameter) tibialis anterior allograft. A switching stick is advanced from posterior on the clavicle to the medial coracoid under arthroscopic visualization. An 8.25-mm cannula dilator is then advanced over the switching stick to create a path for the graft. A shuttling stitch is then passed through the dilator and retrieved out the anteroinferior portal. Similarly, the switching stick is then advanced from anterior on the clavicle to the lateral coracoid, and a second shuttling stitch is passed.

The graft is then passed, first using the medial shuttling stitch for passage of the conoid limb, followed by the lateral shuttling stitch for passage of the trapezoid limb. This creates a loop under the coracoid at the level of the previously abraded inferior bony surface. The superior clavicle fixation device is then advanced onto the limbs of the suture.

The graft is then cycled to remove creep. The distal clavicle is then manually reduced, and a surgical assistant aids in maintaining AC joint reduction which is confirmed with fluoroscopy. Reduction of the AC joint and restoration of the normal CC interval are performed using the suture and button construct; the suture ends are then cut from the superior clavicle knotless fixation device. The free ends of the soft tissue graft are then looped in an overhand fashion and subsequently secured with several high-strength sutures placed through the knotted graft (Fig. 20.9).

Loss of reduction is one of the most common complications associated with CC ligament reconstruction. Therefore, it is important to ensure maintenance of AC joint reduction with intraoperative passive shoulder motion. A dynamic examination is performed under direct arthroscopic evaluation and supplemented by fluoroscopic evaluation.

The superior AC joint capsule is then imbricated, and the deltotrapezial fascia is securely repaired. Augmentation of this repair may be performed by incorporation of the soft tissue graft or with an internal brace construct. This is typically added in

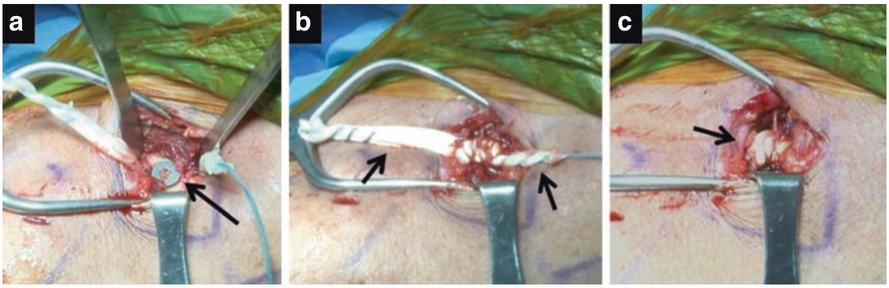

Fig. 20.9 (**a**) The knotless AC construct (arrow) has been secured and the allograft passed around the coracoid, (**b**) the tails of each end of the allograft (arrows) are tied over the top hat, and (**c**) the free ends are cut, and the final construct is demonstrated (arrow) on the right shoulder with the patient placed in the beach chair position

Table 20.2 Surgical pearls for coracoclavicular ligament reconstruction

A 70° arthroscopic camera allows visualization of the subcoracoid space
Avoid soft tissue dissection distal to the coracoid tip
Perform a distal clavicle resection, 8–10 mm, for patients with arthritis or incongruent joints
Soft tissue dilators may be used over a switching stick to create a path for the graft

chronic cases, cases where there is a lot of force on the reduction, and in cases in which there is considerable anteroposterior translation even after the CC ligaments have been reconstructed. The primary incision is then closed in layers using absorbable sutures. Surgical pearls to aid in a successful reconstruction are outlined in (Table 20.2).

Postoperative Overview

To minimize tension on the CC ligament reconstruction, an abduction sling is used for the first 4–6 weeks. Supine passive range-of-motion exercises are initiated in the immediate postoperative period. Active and active assisted motion is delayed until 6 weeks following surgery, and strengthening is delayed until 8 weeks. Return to full activities is usually allowed at 16 weeks postoperatively.

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Part VI

Glenohumeral Osteoarthritis

21

Comprehensive Arthroscopic Management of Glenohumeral Osteoarthritis (CAM Procedure)

Jonathan A. Godin, Erik M. Fritz, and Peter J. Millett

Introduction/Background

Glenohumeral osteoarthritis is a common cause of shoulder pain and dysfunction. The initial treatment typically consists of non-operative modalities, including physical therapy, nonsteroidal anti-inflammatories (NSAIDs), injections, and activity modification. When non-operative treatment fails, surgical options include arthroscopic debridement, biological interposition arthroplasty, hemiarthroplasty, total shoulder arthroplasty (TSA), and reverse total shoulder arthroplasty (RTSA). While TSA offers a predictable solution for many patients who have end-stage glenohumeral arthrosis, the outcomes of TSA have been reported to be less favorable in younger patients because of higher activity demands, increased expectations, concerns for implant longevity, and the potential need for multiple revision operations over the course of the patients' lifetimes. As a result, arthroscopic techniques have evolved in an attempt to preserve the native joint and postpone joint replacement by improving pain and function.

Indications

Young, high-demand patients with moderate to severe glenohumeral osteoarthritis.

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Contraindications

Patients with an active glenohumeral septic arthritis. Elderly patients with severe glenohumeral osteoarthritis and cuff tear arthropathy, in whom shoulder arthroplasty is indicated.

Operative Principle

The comprehensive arthroscopic management procedure includes a combination of arthroscopic glenohumeral debridement, chondroplasty, synovectomy, loose body removal, humeral osteoplasty with excision of the goat's beard osteophyte, capsular releases, subacromial and subcoracoid decompressions, axillary nerve decompression, and biceps tenodesis. The procedure has been shown to reduce pain, improve function, and provide a predictable short-term, joint-preserving option for patients with advanced glenohumeral osteoarthritis. A unique feature of the CAM procedure is the indirect and direct decompression of the axillary nerve, which may explain the difference in outcomes with this technique compared to those of other approaches.

Surgical Technique

Preoperative Preparation

An interscalene regional catheter is placed in the preoperative holding area. General anesthesia is induced, and the patient is brought into the beach chair position. The surgeon examines both shoulders with the patient under anesthesia, carefully noting the preoperative range of motion. Range of motion deficits due to capsular contracture, identified as a deficit of greater than 15° in any plane, are noted to assist with planning of subsequent capsulotomies. In our experience, loss of abduction correlates with the size of the inferior osteophyte on the humeral head, and removal of this osteophyte can improve range of motion. A fluoroscopic C-arm is then positioned to allow for intraoperative imaging (Fig. 21.1). Fluoroscopic images are obtained to ensure that the full extent of the inferior humeral osteophyte can be visualized with internal and external rotation of the arm. The operative extremity is then prepped and draped in sterile fashion before placing it in a pneumatic arm holder. Of note, the C-arm is sterilely draped into the field.

Diagnostic Arthroscopy

A posterior viewing portal is placed approximately 2 cm medial and 2 cm inferior to the posterolateral corner of the acromion, and a 30° arthroscope is introduced.

Fig. 21.1 A fluoroscopic C-arm is draped into the surgical field. Fluoroscopic images should be taken prior to starting the procedure to ensure the full extent of the inferior humeral osteophyte can be visualized with internal and external rotation of the arm

Under direct visualization, a spinal needle is used to place an anterosuperior working portal with a 5 mm cannula through the rotator interval. A diagnostic arthroscopy is subsequently performed. Entry into the subacromial space is avoided until the decision to perform inferior humeral osteoplasty, capsular release, and axillary nerve neurolysis is made, as this avoids excessive extra-articular fluid extravasation that can make the safe completion of these procedures within the inferior capsular recess more difficult. The long head of the biceps tendon is examined by drawing it into the joint with an arthroscopic probe. If tenosynovitis, pulley injury, hourglass deformity, or a degenerative SLAP injury is appreciated, then tenotomy is performed near the origin for later open subpectoral biceps tenodesis.

Glenohumeral Debridement, Chondroplasty, Microfracture, Loose Body Removal, and Synovectomy

After completion of diagnostic arthroscopy, unstable chondral margins and degenerative fraying of the labrum are carefully debrided and stabilized with a mechanical shaver. A radiofrequency (RF) cautery is used to debride hypertrophied synovium and synovitis and to release adhesions within the rotator interval. Well-shouldered isolated Outerbridge grade IV chondral lesions are treated with microfracture. The calcified cartilage layer is debrided with a curette, and the underlying bone is perforated with microfracture picks, taking care to keep the holes close enough to maintain a subchondral plate depth of 2–4 mm between perforations (Fig. 21.2). After completion of the microfracture, inflow is temporarily stopped to ensure that the holes are deep enough to allow the egress of marrow, fat droplets, and blood. When encountered, chondral loose bodies are removed with an arthroscopic grasper or morselized and suctioned from the joint with a mechanical shaver.

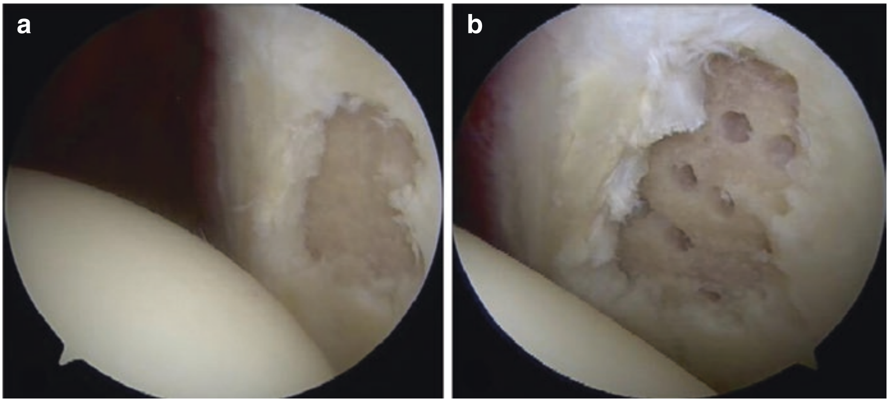

Fig. 21.2 View of the glenoid through the posterior viewing portal before (**a**) and after (**b**) microfracture has been performed in a left shoulder. Note the distance between perforations

Fig. 21.3 A large humeral inferior osteophyte (goat's beard osteophyte) (asterisk) can be visualized on this radiograph. Live fluoroscopy with dynamic examination of the arm with internal and external rotation is an excellent adjunct to direct arthroscopic visualization of the axillary capsular recess to ensure that the osteophyte is completely resected

Humeral Osteoplasty

If a large inferior humeral osteophyte (goat's beard deformity) is identified radiographically (Fig. 21.3), then humeral osteoplasty is performed.

An accessory posteroinferolateral – or 7-o'clock – portal is created approximately 5 cm inferior to the posterolateral aspect of the acromion to facilitate access to the inferior axillary capsular recess (Fig. 21.4).

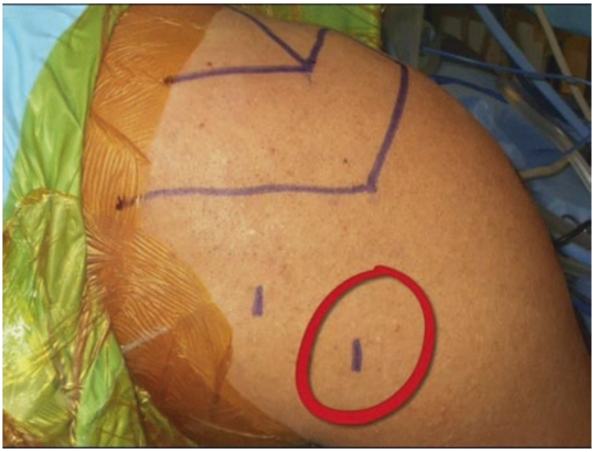

Fig. 21.4 An accessory posteroinferolateral or 7-o'clock portal (circle) is created to facilitate access to the inferior axillary capsular recess. Portal placement under direct visualization and maintaining its position with a winged cannula are critical to avoid iatrogenic nerve injury

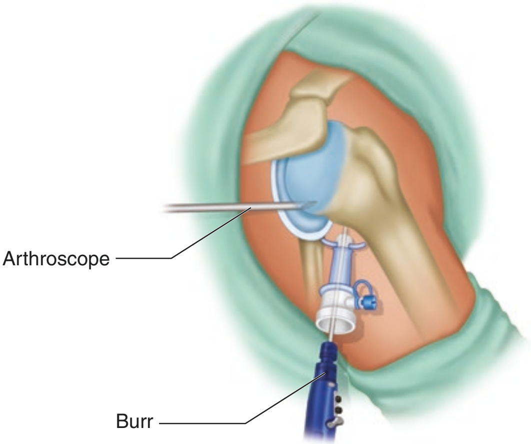

Fig. 21.5 Humeral osteoplasty performed with a shielded bur placed through an accessory posteroinferolateral (7-o'clock) portal while viewing posteriorly with the arthroscope

This portal is created after localization with an 18-gauge spinal needle approximately at the junction of the medial and central thirds of the inferior capsule, just anterior to the posterior band of the inferior glenohumeral ligament. A superficial skin incision is made, and a 2.6-mm switching stick is then used to bluntly recreate the path of the spinal needle to avoid iatrogenic injury to the axillary nerve. Once the trajectory is established bluntly, dilators are used to allow access with an 8.25-mm cannula equipped with deployable wings to prevent back out.

The osteophyte is resected with a shielded burr through the 7-o'clock portal (Fig. 21.5). The inferior capsular tissue is preserved during osteophyte resection to protect the axillary nerve from injury, as well as to prevent excessive fluid extravasation. The arm is periodically internally and externally rotated and examined fluoroscopically to help guide the resection (Fig. 21.6a). Curved curettes can be used to help with osteophyte removal. The final resection is smoothed with a rasp. The goal is to remove enough bone so that the axillary nerve is decompressed throughout full range of motion of the shoulder (Fig. 21.6b).

Capsular Releases and Axillary Nerve Neurolysis

The extent of the capsular releases is determined by preoperative range of motion and the need to access the axillary nerve for neurolysis. After completion of the humeral osteoplasty, the inferior capsulotomy is started posteriorly near the cannula insertion site with a monopolar hook-tip RF device or arthroscopic scissors under direct visualization (Fig. 21.7). Both 30° and 70° arthroscopes can be used to facilitate visualization.

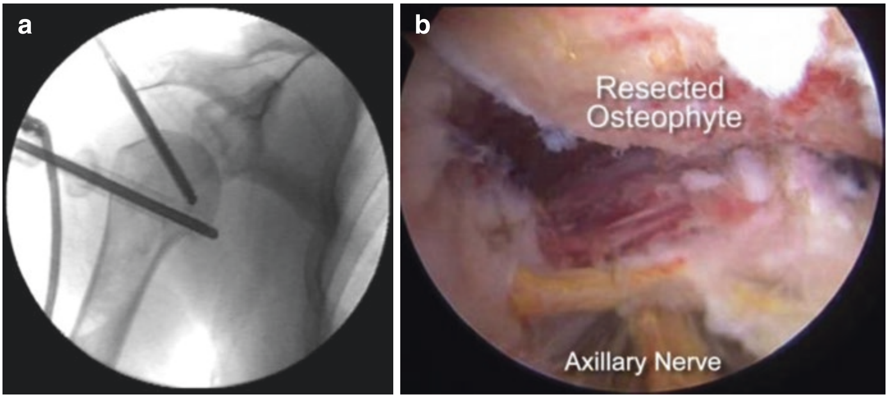

Fig. 21.6 (**a**) Fluoroscopic guidance is used during osteophyte resection. To facilitate resection, the arm should be periodically internally and externally rotated. Curved curettes can be used to remove bone from anteroinferior areas that are difficult to access with motorized instruments. (**b**) View of the resected osteophyte through the posterior portal in a right shoulder. The proximity of the axillary nerve to the resected osteophyte should be noted

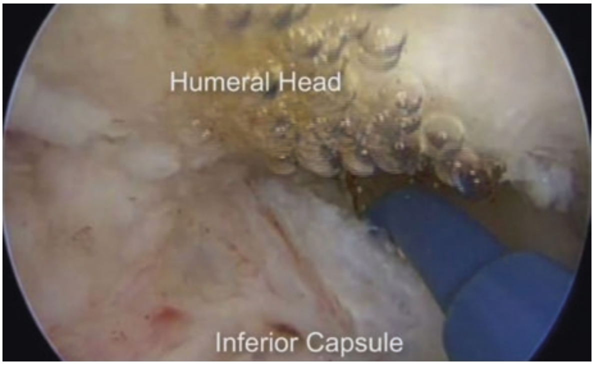

Fig. 21.7 View through the posterior portal with instrumentation in the 7-o'clock portal in a right shoulder. An inferior capsular release is performed with a hook-tip RF device. The release should be started posteriorly near the cannula insertion site

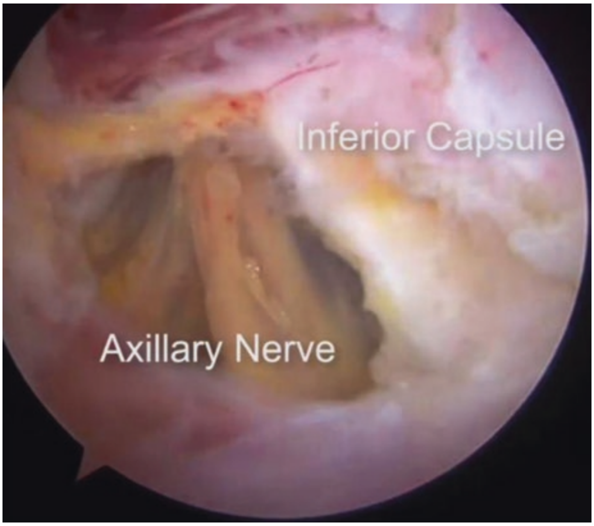

Fig. 21.8 The inferior capsule and axillary nerve are visualized through the posterior portal in a left shoulder. Axillary nerve neurolysis should be performed from proximal to distal to prevent iatrogenic injury. The neurolysis is considered complete when the nerve is visualized to be free of surrounding soft tissue adhesions and bony impingement

The neurolysis is then performed, releasing the axillary nerve from proximal, as it courses inferiorly to the subscapularis tendon, to distal, as it courses between the teres minor and major tendons (Fig. 21.8). The neurolysis is performed bluntly under direct visualization with a probe and arthroscopic punches, moving along the axillary nerve's course from proximal to distal to prevent iatrogenic injury as it arborizes. The neurolysis is complete when the nerve is visualized to be free of surrounding soft tissue adhesions and bony impingement.

Anterior and posterior capsulotomies are performed as indicated. After debridement of scar and synovitis within the rotator interval, the anterior capsule is divided from the rotator interval to the 5-o'clock position with an RF probe just lateral to the labrum. The muscle fibers of the subscapularis can be visualized, and it is important to work carefully to avoid damage to the subscapularis. If necessary, the arthroscope is repositioned through the anterosuperior portal, and posterior capsular release is performed from the 7- to 11-o'clock position in a similar fashion (Fig. 21.9). The arm is then re-examined and gently manipulated to assess restoration of passive motion.

Additional Procedures

Subacromial decompression, subcoracoid decompression, and biceps tenodesis are selectively performed as indicated. Regarding subcoracoid decompression, if the coracohumeral interval is less than 8 mm in female patients or less than 10 mm in male patients, coracoplasty is performed with an arthroscopic burr. The arthroscope is then inserted into the subacromial space through the posterior portal, and a subacromial bursectomy is performed. Acromioplasty is performed with a modified cutting block technique if a type III acromion or impingement lesion is identified. If

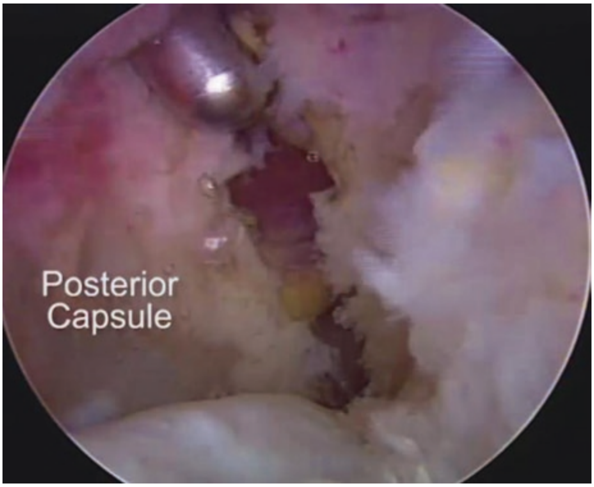

Fig. 21.9 Posterior capsular release as viewed through the anterior portal with instrumentation in the posterior portal in a right shoulder

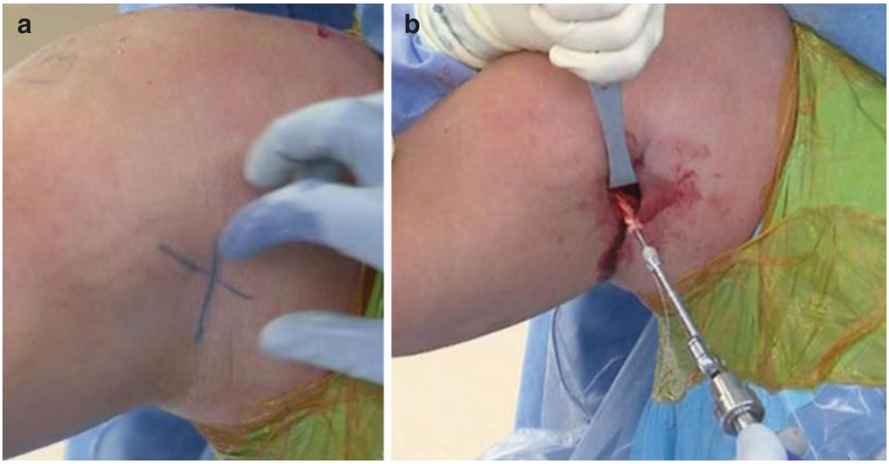

Fig. 21.10 (**a**) The incision for the subpectoral biceps tenodesis is made in the axillary fold distal to the inferior margin of the pectoralis major tendon. The plane between the conjoint and pectoralis tendons is then developed. (**b**) The previously tenotomized biceps tendon is retrieved. It is whip-stitched approximately 2.5 cm proximally from the musculotendinous junction. A 7-mm unicortical socket is created in women, whereas an 8-mm unicortical socket is created in men. The biceps tendon is loaded onto a PEEK tenodesis screw for interference fixation

the long head of the biceps tendon was tenotomized, the procedure is concluded with an open subpectoral biceps tenodesis. Our preferred technique is to place a small cosmetic incision in the axillary fold (Fig. 21.10a), identify and deliver the tendon from the interval between the pectoralis major and conjoint tendons, and fix the tendon in a 7- or 8-mm unicortical socket with a PEEK (polyether ether ketone) tenodesis screw (Fig. 21.10b).

Pearls and Pitfalls

Pearls	Pitfalls
Work from medial to lateral and proximal to distal while decompressing the axillary nerve	Failure to take the utmost caution when working around the axillary nerve increases the risk of iatrogenic nerve damage
Use a blunt trocar to separate the axillary nerve from scar tissue and capsule	Inadequate fluoroscopic and arthroscopic views can lead to incomplete humeral head osteoplasty
Use a cannula to shield the neurovascular structures	Prolonged operative time may lead to fluid extravasation into the axillary space
Perform capsular releases after inferior humeral osteoplasty and axillary nerve neurolysis	
Use moderate arthroscopic pump pressures	
Use fluoroscopy and both 30° and 70° arthroscopes to assist visualization; use long curettes to remove bone. There are, however, some cases in which a complete excision may not be safe or possible	

Postoperative Rehabilitation

The rehabilitation program is initiated immediately postoperatively and is facilitated in most cases by the preoperative placement of a regional block for pain control. The goals of rehabilitation are to improve and maintain range of motion, prevent scarring and contracture, and improve glenohumeral and scapulothoracic mechanics. The first of three phases emphasizes passive and active assisted motion. The second phase, focusing on strengthening, ensues around 4–6 weeks postoperatively. The final phase, focusing on functional return to activities, is initiated at approximately 3 months postoperatively. Maximal recovery can be expected by 4–6 months.

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Part VII

Additional Pathologies and Procedures

Arthrolysis: Capsular Release for Adhesive Capsulitis

22

Burak Altintas, Gilbert Moatshe, Erik M. Fritz, and Peter J. Millett

Introduction/Background

Frozen shoulder can lead to significant pain and disability. The cause of this condition is unknown, although it is common in patients with systemic diseases such as diabetes and thyroid disease. Shoulder stiffness can also occur after a period of immobilization after shoulder injury or surgery. It is commonly seen in patients over the age of 40 years, and females are more likely to have frozen shoulder than males. Surgical treatment is recommended after failed conservative therapy. Although manipulation under anesthesia is also an option for these cases, arthroscopic capsular release has the advantage of clear visualization and controlled release of the adhesions in a minimally invasive fashion.

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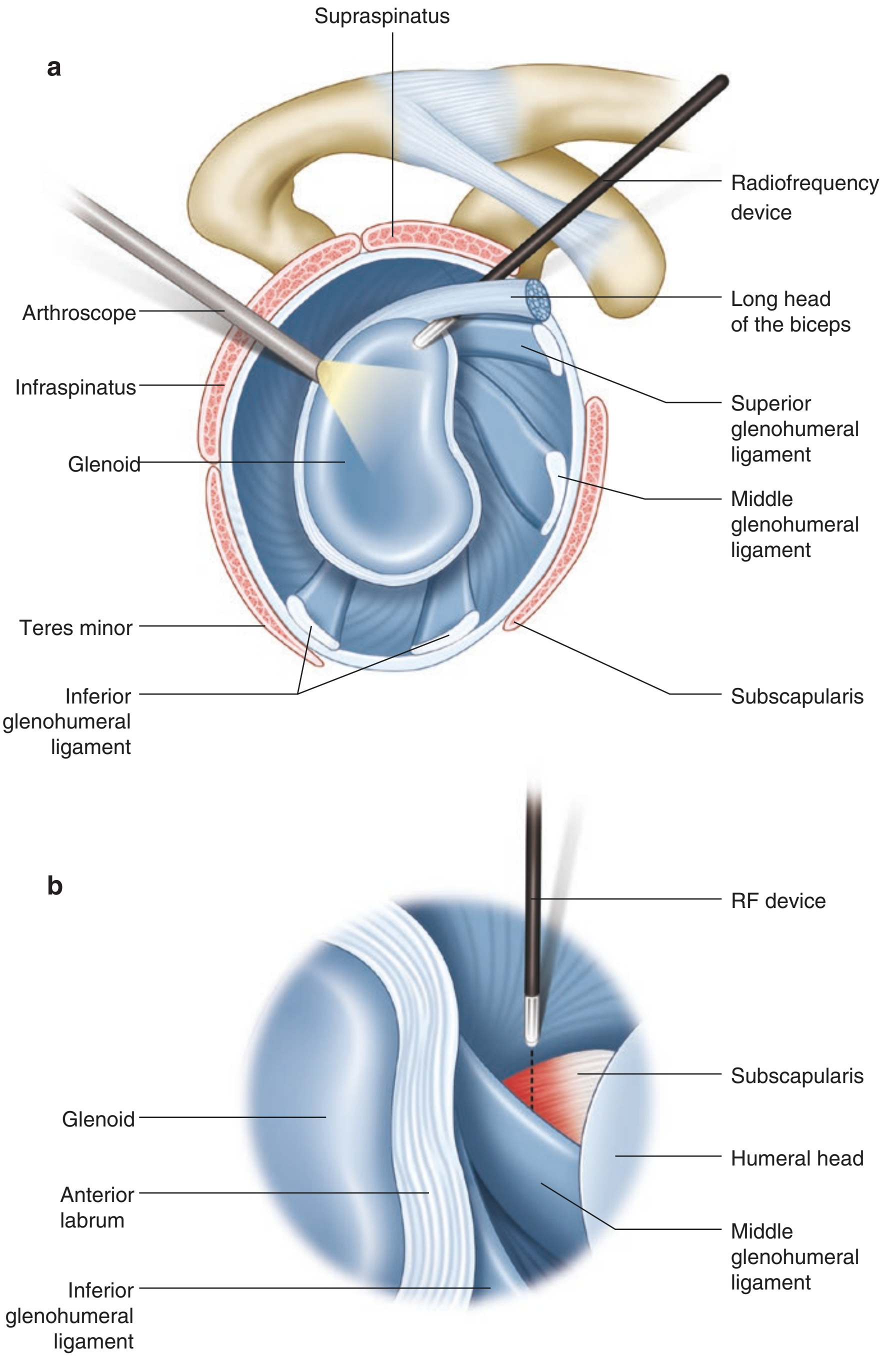

Fig. 22.1 (**a**) Sagittal view of a right shoulder demonstrating the portals and instruments in relation to the topographic anatomy. Due to the possible presence of adhesions, the anterosuperior portal should be placed as high as possible to prevent injury to the subscapularis tendon and for easier instrumentation. (**b**) Arthroscopic view of the same shoulder from the posterior portal. Note the interval between the subscapularis and the middle glenohumeral ligament

Operative Principle

The release of the capsular adhesions restores motion and thus improves shoulder function (Fig. 22.1).

Indications

Arthroscopic capsular release is indicated in patients with adhesive capsulitis who do not improve after conservative management.

Contraindications

The contraindications for surgical repair are patients in the inflammatory phase of the disease.

Technique

Preoperative Preparation

After the induction of general anesthesia and placement of a regional interscalene block, the patient is placed in the beach-chair position. An examination under anesthesia is performed to assess the shoulder's range of motion. The operative extremity is then placed in a pneumatic arm holder with 20° of forward flexion and 50° of abduction. The operative shoulder and axilla are prepared and draped using standard sterile techniques. If there is concern for an infectious cause, preoperative antibiotics should be held until thorough diagnostic arthroscopy is performed and tissue biopsies are obtained for microbiological and pathological analysis to rule out low-grade infection.

Diagnostic Arthroscopy

Standard posterior and anterosuperior portals are created. As the capsule is thicker and less compliant than in other conditions, the posterior introduction of the trocar and sheath should be done carefully to prevent iatrogenic damage to the articular surfaces. Due to the possible presence of adhesions, the anterosuperior portal should be placed as high as possible to prevent injury to the subscapularis tendon and for easier instrumentation. A standard diagnostic arthroscopy is performed with

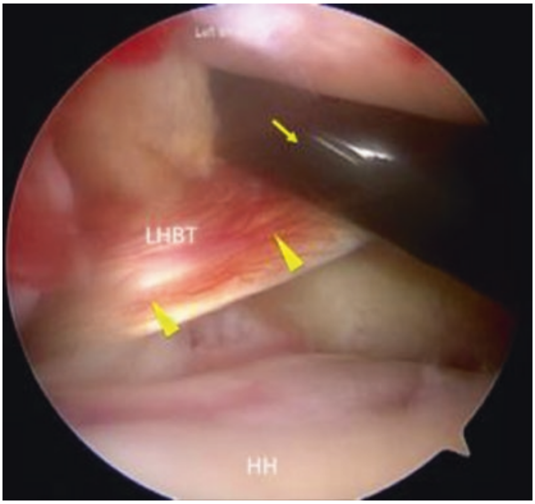

Fig. 22.2 Arthroscopic view of the left shoulder through the posterior portal. Via the anterosuperior portal, the radiofrequency device (yellow arrow) is used to inspect the long head of the biceps tendon (LBHT) to reveal significant tenosynovitis of the tendon (arrowheads). HH humeral head

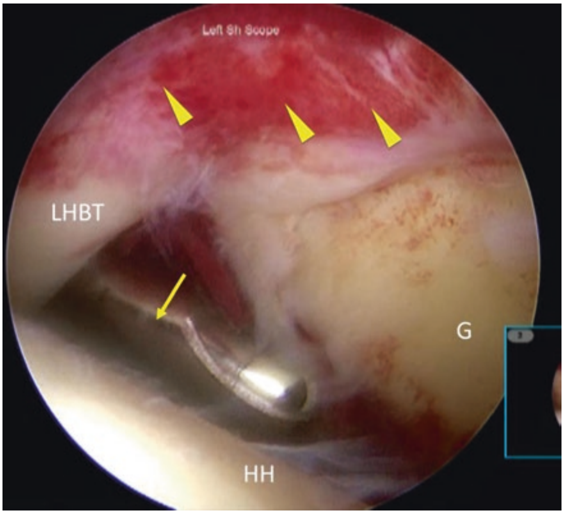

Fig. 22.3 Arthroscopic view of the left shoulder through the posterior portal. Via the anterosuperior portal, an arthroscopic shaver (yellow arrow) is used to debride the frayed labrum. Note the significant synovitis (yellow arrowheads). G glenoid, HH Humeral head, LHBT long head of the biceps tendon

assessment of the biceps tendon, labrum, articular surfaces, and rotator cuff (Fig. 22.2). The visualization of the subscapularis tendon may be difficult because of proliferative synovitis (Fig. 22.3).

Release of the Rotator Interval

In case of suspected infection, biopsies should be taken from the synovium along the anterior capsule and glenohumeral ligaments to rule out a bacterial genesis. For the anterior release, the shoulder should be placed in external rotation. The capsular release begins at the rotator interval as the differentiation of the subscapularis from the surrounding adhesions may be difficult. For this, a

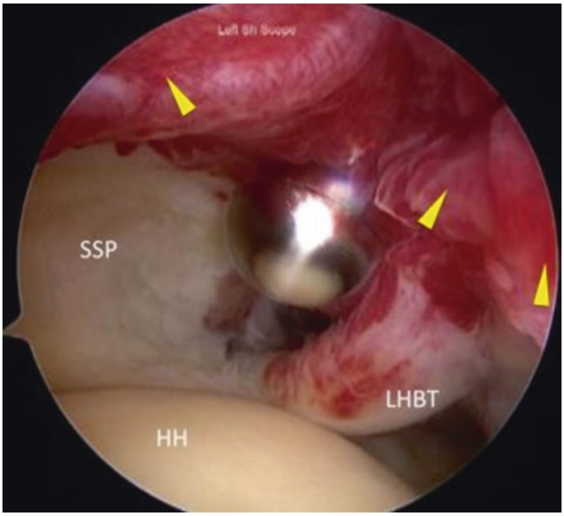

Fig. 22.4 Arthroscopic view of the left shoulder through the posterior portal demonstrating the significant intraarticular synovitis (yellow arrowheads). LHBT long head of the biceps tendon, HH humeral head, SSP supraspinatus tendon

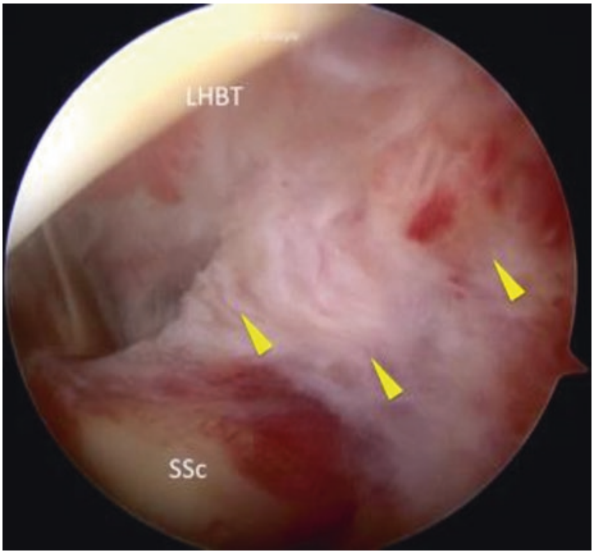

Fig. 22.5 Arthroscopic view of the left shoulder through the posterior portal. Adhesions (yellow arrowheads) within the rotator interval and superior to the subscapularis tendon (SSc) are visualized here. LHBT long head of the biceps tendon

radiofrequency device is introduced through the anterosuperior portal (Fig. 22.4). The rotator interval and the coracohumeral ligament are divided parallel to the glenoid until the upper border of the subscapularis can be visualized (Fig. 22.5). Next, the interval is released medially parallel to the upper border of the subscapularis. Care must be taken not to injure the labrum or the subscapularis. After identifying the anterior arthroscopic triangle, a 5.5 mm shaver and a radiofrequency device are used to debride the rest of the rotator interval and the coracohumeral ligament (Fig. 22.6).

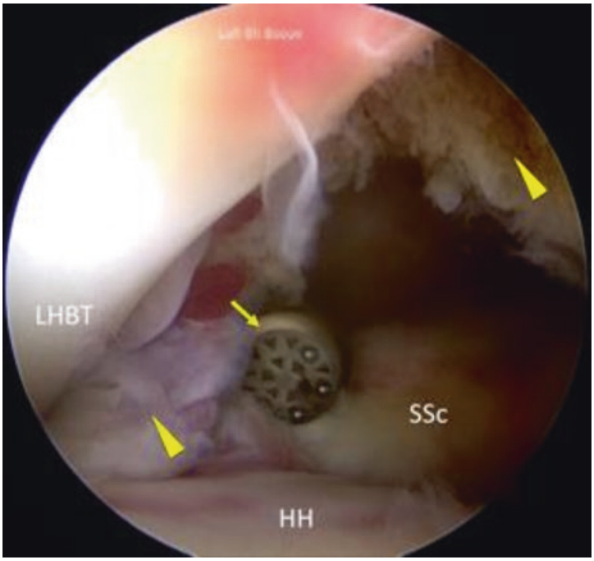

Fig. 22.6 Arthroscopic view of the left shoulder through the posterior portal. The scope is positioned laterally in the shoulder to view the rotator interval. A radiofrequency device (yellow arrow) is used to remove the adhesions (yellow arrowheads) in the area. HH humeral head, LHBT long head of the biceps tendon, SSc subscapularis tendon

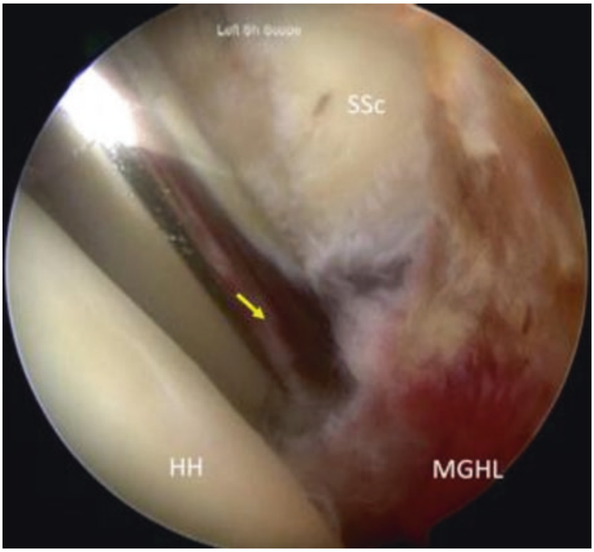

Fig. 22.7 Arthroscopic view of the left shoulder through the posterior portal. An arthroscopic shaver (yellow arrow) is used to resect the significantly inflamed middle glenohumeral ligament (MGHL). HH humeral head, SSc subscapularis tendon

Release of the Glenohumeral Ligaments

The interval between the subscapularis and the middle glenohumeral ligament (MGHL) is identified and released with a 5.5 mm shaver**.** To prevent damage to the subscapularis, the shaver should be directed parallel to the glenoid surface

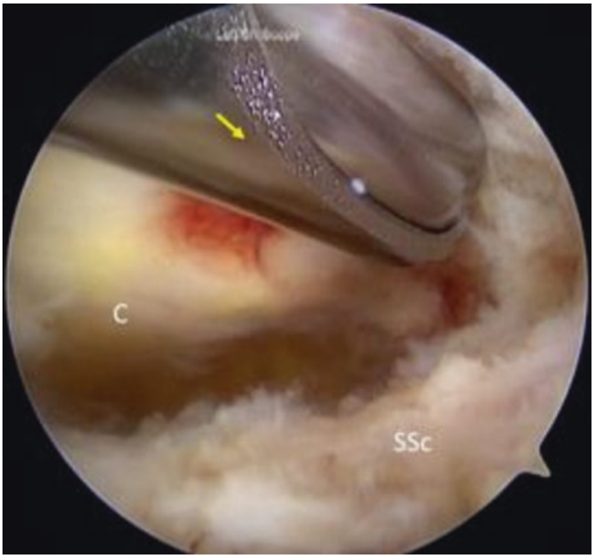

Fig. 22.8 Arthroscopic view of the left shoulder through the posterior portal. The scope is positioned to view the space anterior to the subscapularis (SSc), while an arthroscopic shaver (yellow arrow) is used to debride the adhesions in the area. C anterior capsule

(Fig. 22.7). This should be carried down to 7 o'clock position (for the left shoulder). If the release of the inferior capsule is necessary, it is done by creating an accessory posteroinferior portal as mentioned in the "Comprehensive Arthroscopic Management" chapter previously. It is important not to perform an extensive capsulotomy as this may result in postoperative instability in this patient group.

Anterior Release of the Subscapularis

After advancing the arthroscope anteriorly, the anterior border of the subscapularis is visualized. The shaver is used for releasing the subscapularis from the anterior capsule (Fig. 22.8).

Posterior Capsular Release

For the posterior release, the shoulder is placed in internal rotation. The arthroscope is then switched to the anterosuperior portal. The posterior release is performed with the radiofrequency device introduced from the posterior portal from 12 o'clock to 5 o'clock (for the left shoulder) position (Fig. 22.9). This must be performed carefully to not injure the infraspinatus (Fig. 22.10). It should be noted that the addition of posterior capsular release may not result in a better outcome compared with anterior capsular release alone. Thus, we prefer to start with anterior and rotator interval release followed by posteroinferior release if the shoulder remains tight.

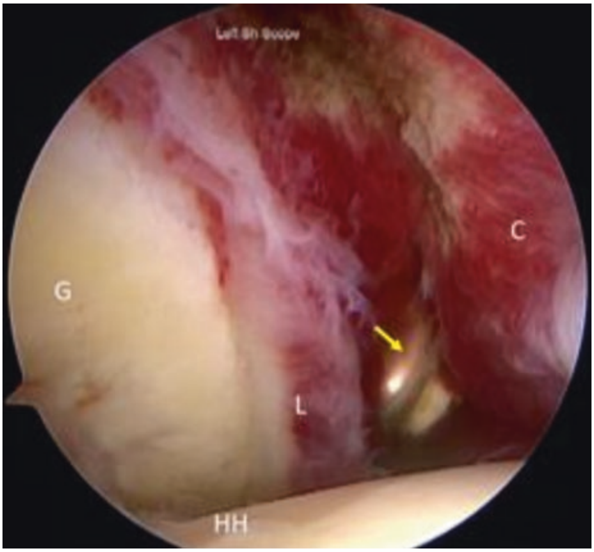

Fig. 22.9 Arthroscopic view of a left shoulder through the anterosuperior portal. Via the posterior portal, a radiofrequency device (yellow arrow) is used to release the posterior capsule (C). G glenoid, HH humeral head, L labrum

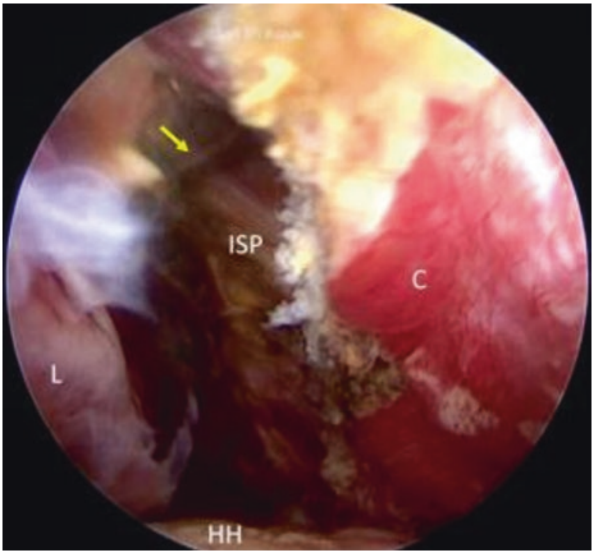

Fig. 22.10 Arthroscopic view of a left shoulder through the anterosuperior portal. Following the posterior capsule release, with the medial capsule fragment retracted by the radiofrequency device (yellow arrow), the fibers of the infraspinatus muscle (ISP) may be seen. Note the significant synovitis of the posterior joint capsule (C). HH humeral head, L posterior labrum

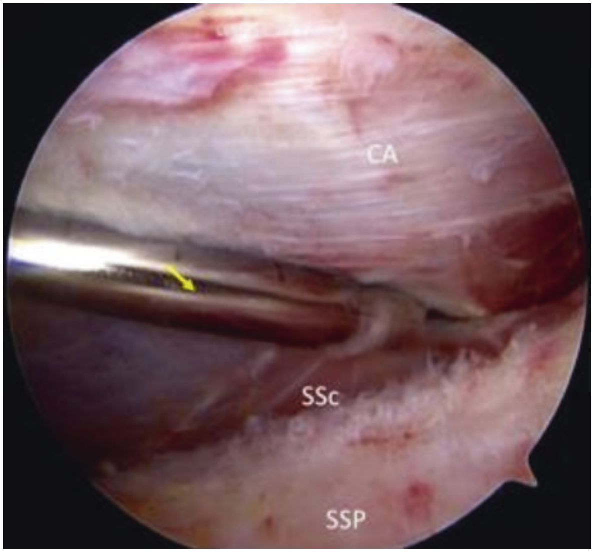

Fig. 22.11 View of the subacromial space via the posterior portal. An arthroscopic shaver (yellow arrow) is used to remove the adhesions in the subacromial space. CA coracoacromial ligament, SSP supraspinatus tendon, SSc subscapularis tendon

Subacromial Evaluation and Decompression

The evaluation of the subacromial space is performed as described in the previous chapter. If needed, subacromial adhesiolysis and acromioplasty should be performed (Fig. 22.11). Afterward, the bursal side of the rotator cuff must be examined for possible tear. Finally, a manipulation under anesthesia is performed, and the final degree of motion is assessed.

Pearls and Pitfalls

Surgical step	Pitfalls	Pearls
Diagnostic arthroscopy	Injury to the articular surface during the introduction of the arthroscope and instruments	Controlled insertion of the trocar and sheath helps prevent iatrogenic cartilage injury
Anterior capsular release	Inability to visualize the subscapularis	Starting the release close to the biceps and coming down to the upper border of the subscapularis helps with the identification
Inferior capsular release	Injury to the axillary nerve	Facing the radiofrequency device away during inferior capsular release facilitates protection of the nerve

Postoperative Management

If there is no concomitant procedure. Additionally, the patient is usually kept on continuous interscalene nerve block for 3–5 days postoperatively. Daily aggressive physical therapy is recommended including full passive and active range of motion.

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23 Neurolysis of the Suprascapular Nerve

Gilbert Moatshe, Erik M. Fritz, and Peter J. Millett

Introduction

Suprascapular neuropathy caused by entrapment is an increasingly recognized pathological entity that can cause shoulder pain and weakness. This clinical entity should always be considered as a differential diagnosis in patients with shoulder pathology including retracted massive rotator cuff tears. Suprascapular neuropathy can also occur as a result of compression on the nerve or traction-related etiology. Understanding the anatomy and a thorough diagnostic workup are important in treating this pathology. Neuropathy caused by traction etiology is reported to be unlikely to respond to surgical management, while compression injuries usually respond well to decompression of the nerve. Early diagnosis and treatment are crucial as chronic compression of the nerve can lead to muscle atrophy and persistent pain.

The suprascapular nerve (SSN) is a branch of the brachial plexus with fibers mainly from the C5 and C6 nerve roots but can also contain contributions from the C4 root. The nerve courses from anteromedial to posterolateral through the suprascapular notch and below the transverse scapular ligament (Fig. 23.1). The suprascapular notch is an important anatomic landmark located just medial to the base of the coracoid process, about 2 cm from the glenoid rim, and 3 cm from the supraglenoid tubercle which is the attachment site of the long head of the biceps (LHB) tendon. From the suprascapular notch, the nerve enters the supraspinatus fossa

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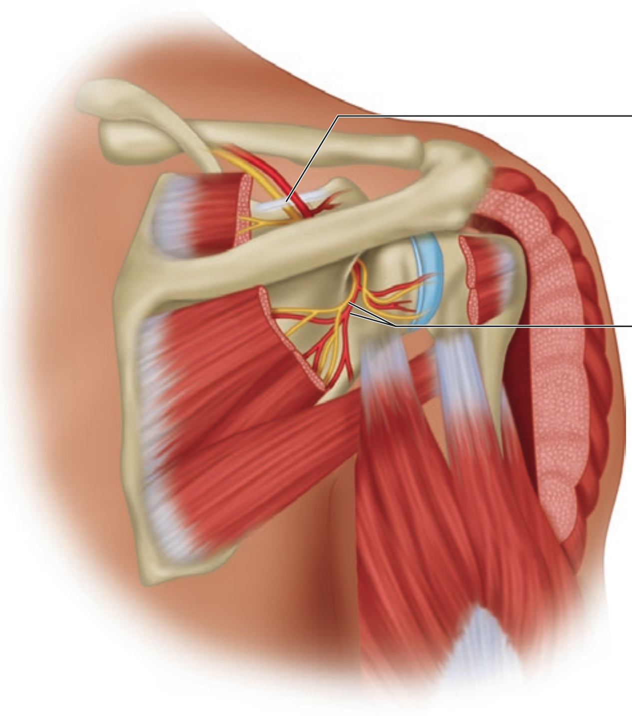

Fig. 23.1 Posterior view. An illustration demonstrating the course of the suprascapular nerve under the transverse scapular ligament and the artery courses above the ligament. From the suprascapular notch, the nerve enters the supraspinatus fossa giving motor innervation to the supraspinatus muscle and sensory innervation to the glenohumeral and the acromioclavicular (AC) joints. The nerve courses around the spine of the scapula at the spinoglenoid notch, under the spinoglenoid ligament, and gives motor innervation to the infraspinatus muscle

giving motor innervation to the supraspinatus muscle and sensory innervation to the glenohumeral and the acromioclavicular (AC) joints. The nerve courses around the spine of the scapula at the spinoglenoid notch, under the spinoglenoid ligament, and gives motor innervation to the infraspinatus muscle. Of note, the motor branches to the supraspinatus are approximately 1 cm from the suprascapular notch, whereas the motor branches to the infraspinatus are about 2 cm from the posterior glenoid rim. Compression of the nerve at the suprascapular notch leads to weakness and atrophy of the supraspinatus and infraspinatus muscles and pain because of the sensory fibers to the glenohumeral and AC joints. The most common cause of nerve entrapment in this area is the transverse suprascapular ligament. Compression of the nerve at the spinoglenoid notch often leads to atrophy of the infraspinatus and isolated external rotation weakness. The symptoms may be vague because of absence of pain and that the teres minor, innervated by axillary nerve, compensates for the external rotation weakness. The pain fibers to the joint branch off proximal to the spinoglenoid notch, which accounts for the absence of pain with suprascapular nerve entrapment at the spinoglenoid notch. Etiology of compression in this area is commonly the spinoglenoid ligament and paralabral cysts.

Diagnosis

A thorough history and examination is mandatory. The diagnosis of suprascapular nerve entrapment can be challenging because of nonspecific symptoms and clinical findings. It is usually a diagnosis of exclusion, and a high level of suspicion is necessary especially in patients with unexplained shoulder pain or weakness. This entity can also be associated with other shoulder pathologies such as massive rotator cuff and posterior labral pathology with paralabral cysts. Some studies have reported that suprascapular neuropathy associated with rotator cuff tears resolve after rotator cuff repair, and nerve decompression is not necessary. However, there are reports of patients who develop suprascapular neuropathy after rotator cuff repair which may necessitate neurolysis. It is important to determine the etiology of the neuropathy because neuropathy caused by traction is treated nonoperatively, while compression injuries usually respond to decompression of the nerve.

- The patient should be examined for range of motion (ROM), muscle strength, and other potential sources of pain and weakness in the shoulder.
- Magnetic resonance imaging (MRI) is important to exclude other causes of pain and weakness and to identify causes of nerve entrapment (Fig. 23.2).

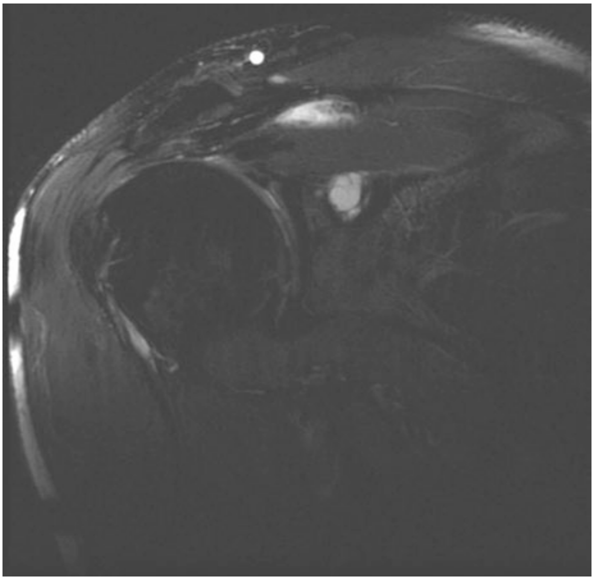

Fig. 23.2 Coronal T1 MR image of a right shoulder demonstrating a large paralabral cyst

- Electromyography (EMG) examination is performed to diagnose nerve pathology and to find the location of entrapment.
- An injection of local anesthetic to the suprascapular notch can also be used to confirm the diagnosis of suprascapular nerve compression as the cause of pain.
- The pain and symptoms must be differentiated from cervical nerve root radiculopathy.

Indications/Contraindications

Surgical indications include pain, usually described as a dull ache which is exacerbated by overhead activities, supraspinatus and/or infraspinatus atrophy and weakness combined with positive EMG findings showing suprascapular nerve entrapment. However, there are some limitations of utilizing EMG including inaccuracy and variability in EMG results, lack of EMG validation, and absence of definitive EMG diagnostic criteria. It is important that there is entrapment etiology that can be improved by nerve release and that there are no other causes of weakness and/or pain.

Contraindications include traction etiology, repeated negative EMG findings, surgical contraindications because of comorbidities and other causes of weakness and pain such as massive rotator cuff tears. These should be evaluated on individual basis.

Operative Principle

If the nerve lesion is proximal and both the supraspinatus and infraspinatus are involved, the entire nerve should be decompressed, but most importantly the transverse scapular ligament should be released. If only the infraspinatus is involved or if there is a structural lesion at the spinoglenoid notch, such as a paralabral cyst, then the nerve may be simply decompressed at the spinoglenoid notch.

Some authors have demonstrated resolution of suprascapular neuropathy with isolated rotator cuff repair without concomitant nerve release has been demonstrated in some studies and therefore routine release of the transverse scapular ligament along with rotator cuff repair is not recommended. In such cases, the suprascapular neuropathy is believed to be caused by traction and possibly tethering of the nerve as the rotator cuff tendons retract medially, and that the traction resolves when the rotator cuff is repaired.

Arthroscopic suprascapular nerve release though it requires advanced arthroscopic skills is preferred because the technique allows for good visualization of the nerve and access, and other concomitant shoulder pathologies such as superior labrum anterior and posterior (SLAP) and labrum lesions can be treated concurrently. A relative contraindication for this technique is transverse scapular ligament calcification or ossification, which can be seen on preoperative radiographs or CT. In patients with calcification or ossification, an open approach is preferred.

Surgical Technique

Preoperative Preparation

After the induction of general anesthesia and placement of a regional interscalene block, the patient is placed in the beach chair position. The operative extremity is then placed in a pneumatic arm holder, and the operative shoulder and axilla are prepared and draped using standard sterile techniques.

Diagnostic Arthroscopy

Standard posterior and anterolateral working portals are created. A diagnostic arthroscopy is performed and intraarticular pathology is addressed.

Arthroscopic Release at the Suprascapular Notch

After a diagnostic arthroscopy and addressing the intraarticular pathology, the arthroscope is placed in an anterolateral portal, and accessory anterior and posterior portals are created (Fig. 23.3). With the arthroscope in the anterolateral portal, the subacromial space can be visualized. A subacromial bursectomy is performed and the coracoid is visualized (Fig. 23.4), followed by meticulous dissection medially. Arthroscopic retractors are helpful to posteriorly retract the supraspinatus muscle belly for better visualization and to create a working space. The dissection is then

Fig. 23.3 Arthroscopic view through the anterolateral portal of the right shoulder subacromial space visualizing the placement of an posterior accessory portal under direct spinal needle localization

carried along the posterior aspect of the coracoid process. The coracohumeral ligament on the lateral aspect of the base of the coracoid process and the coracoclavicular ligaments at the superior base of the coracoid process are identified. It is important to preserve these ligaments. At the medial base of the coracoid process, the suprascapular notch can be identified. The artery is protected or cauterized using radiofrequency ablation, and the ligament is released using handheld arthroscopic tissue punches (Fig. 23.5). The suprascapular nerve is then probed to insure that there is no compression. The nerve can be visualized distally as it courses deep to the supraspinatus muscle.

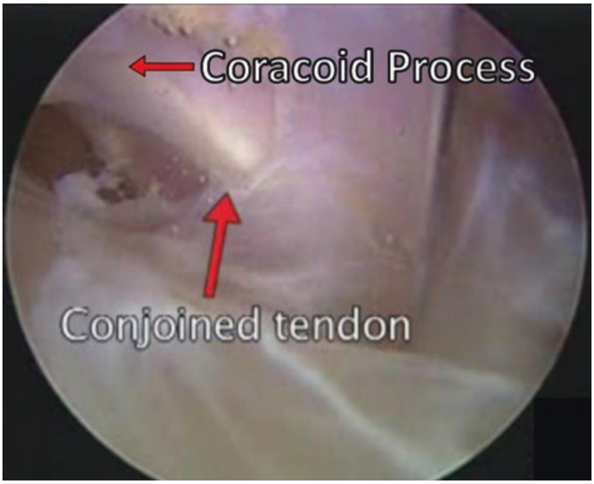

Fig. 23.4 Arthroscopic view of a right shoulder subacromial space through the lateral portal visualizing the conjoint tendon and the coracoid process

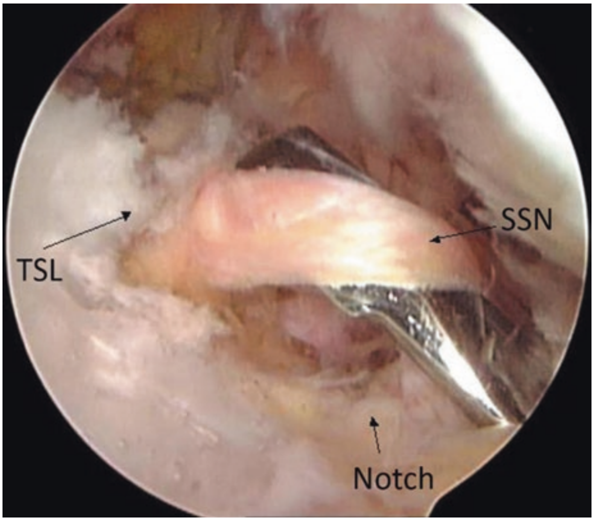

Fig. 23.5 Arthroscopic view of the right shoulder in the subacromial space through the posterolateral portal. With the elevator in the anterolateral portal, the suprascapular nerve (SSN) is inspected at its location in the suprascapular notch (Notch) following resection of the transverse scapular ligament (TSL)

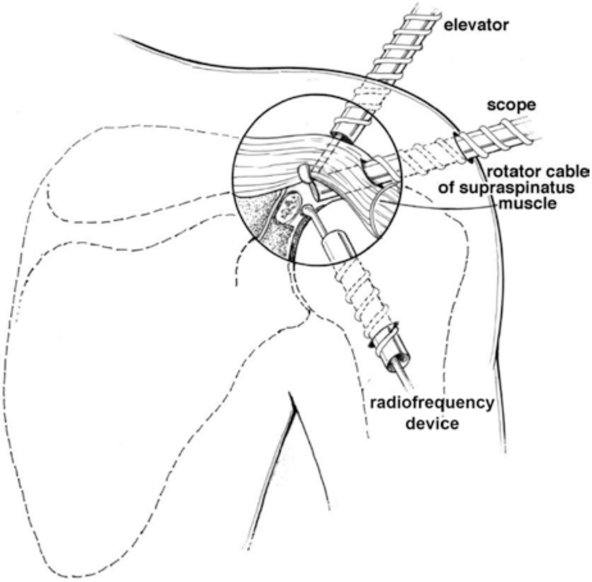

Fig. 23.6 Illustration of the portal sites for spinoglenoid cyst decompression or ligament release

Arthroscopic Release at Spinoglenoid Notch or Cyst Decompression

The patient is placed in the beach chair position after induction of general anesthesia and placement of a regional interscalene block. Standard anterior and posterior portals are created. A trans-rotator cuff portal is created (Fig. 23.6). The arthroscope is then placed through the trans-rotator cuff portal because this gives excellent visualization. If there is a labral tear, it is repaired with suture anchors using standard technique. While some have advocated working through the labral tear to access the cyst, this can be challenging, and visualization of the suprascapular nerve from this position is difficult. Our preferred technique is to repair the labral tear, and then a posterosuperior capsulotomy is performed on the periphery of the labrum leaving the labrum intact (Fig. 23.7). The supraspinatus muscle can now be visualized and superiorly elevated using a retractor placed through the anterior portal (Fig. 23.8). With the supraspinatus muscle elevated and meticulously dissected, the paralabral cyst can be identified and resected (Fig. 23.9). The suprascapular nerve can be identified runs 2.5–3 cm medial to the superior aspect of the glenoid at the base of the supraspinatus fossa. The nerve is visualized, and it can be followed posteriorly as it passes through the spinoglenoid notch. Using handheld basket punches and arthroscopic probes, a careful neurolysis can be performed to release the nerve from underneath the spinoglenoid ligament (Fig. 23.10).

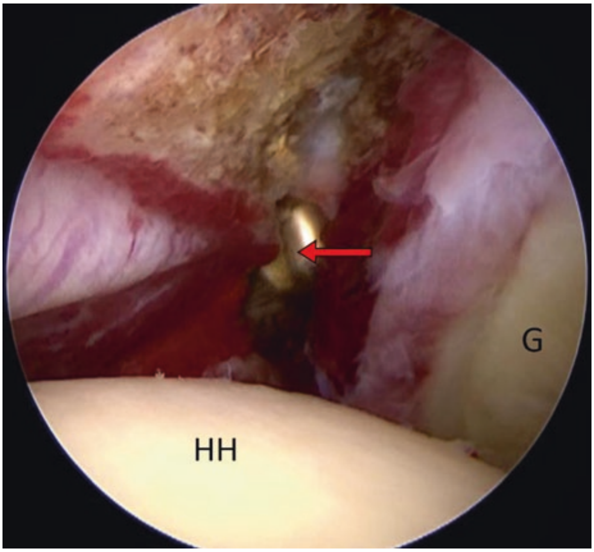

Fig. 23.7 Arthroscopic view of the right shoulder through the anterior portal demonstrating the supero-posterior capsulotomy using a radiofrequency ablator (arrow) through the posterior portal. G glenoid, HH humeral head

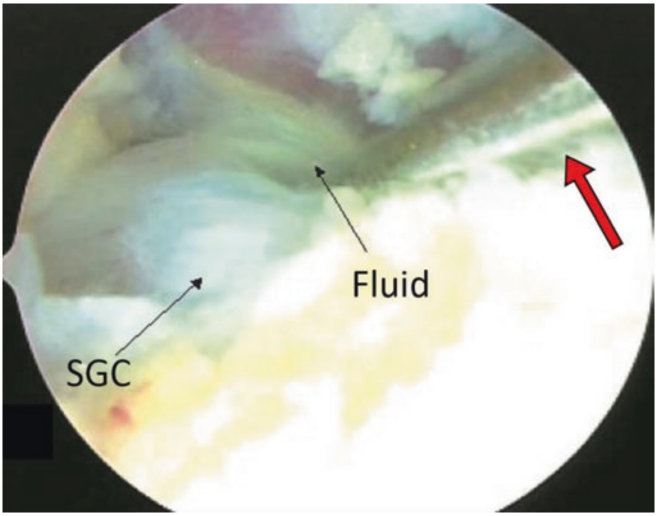

Fig. 23.8 Arthroscopic view of the right shoulder from posterior portal visualizing the supraglenoid cyst (SGC). Instrument (red arrow) seen perforating the supraglenoid cyst from the lateral trans-cuff portal. Cystic fluid (Fluid) is visualized as it flows from the perforation

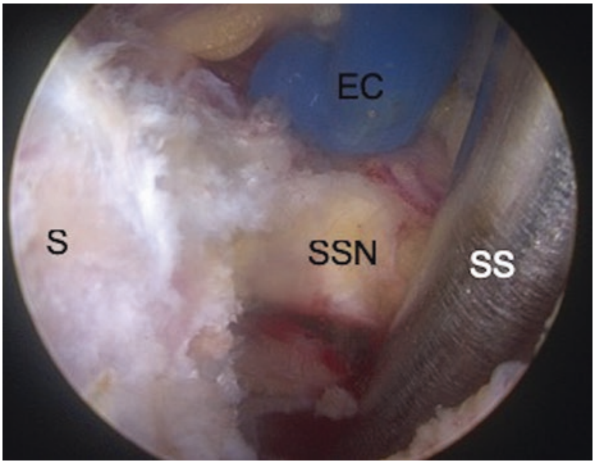

Fig. 23.9 Arthroscopic view of a left shoulder visualizing the suprascapular nerve (SSN) just medial to the coracoid process and 2–3 cm medial to the glenoid rim. *EC* electro cautery, *S* Scapula, *SSN* suprascapular nerve, *SS* switching stick

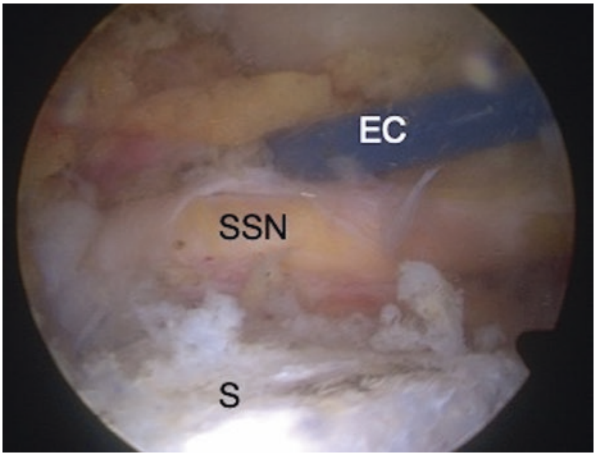

Fig. 23.10 Arthroscopic view of a left shoulder through the posterior portal following resection of the spinoglenoid ligament. The suprascapular nerve (SSN) is exposed and visualized at the spinoglenoid notch. *EC* electro cautery, *S* Scapula, *SSN* suprascapular nerve

Pearls	Pitfalls
Consider this entity as a differential diagnosis in patients with pain and weakness	Failure to acknowledge this pathology
If present with a retracted rotator cuff tear, neurolysis not routinely recommended	Neurovascular injuries
Use EMG to determine the location of the lesion	Injury to the conoid ligament during dissection
Good knowledge of anatomy is important. The artery runs over the transverse ligament and the SSN runs below it	
Calcified transverse scapula ligament is best released by open surgery	

Postoperative Rehabilitation

Postoperatively, patients are immobilized in a sling for comfort. Early motion is encouraged. If a labral tear was repaired, the repair is protected for 6 weeks before resuming active motion. Strengthening begins at 6 weeks, and overhead activities can commence at 4–5 months postoperatively.

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Scapulothoracic Bursectomy

24

George F. LeBus, Zaamin B. Hussain, and Peter J. Millett

Introduction/Background

Scapulothoracic bursectomy is an arthroscopic procedure indicated for recalcitrant scapulothoracic bursitis or snapping scapula syndrome (SSS), a rare diagnosis which can range from a nuisance in some patients to a cause of severe, debilitating morbidity in others. Young, active patients who perform repetitive overhead activities are most commonly affected, and etiologies include chronic overuse, predisposing scapular or thoracic anatomical variants, muscle abnormalities, and bony or soft tissue masses. Chronic overuse even in the absence of anatomic abnormalities can produce inflammation of the bursa and surrounding musculature which can cause reactive bursitis and scarring, particularly in overhead athletes. Bursal fibrosis with secondary scarring can be painful and can even lead to palpable and audible "snapping" symptoms. The most commonly involved bursae in SSS are those at the superomedial angle of the scapula. Anatomic variations, including thinner muscle bulk on the medial border of the scapula, a superomedial bare area on the costal surface of the scapula, scapular morphology, anteriorly angled medial border of the scapula, decreased scapulocostal distance, a prominent Luschka's tubercle, excessive thoracic kyphosis or scoliosis, and even posttraumatic conditions such as malunion of the scapula or underlying ribs, can cause or contribute to scapulothoracic bursitis or snapping scapula syndrome. Muscular abnormalities can manifest as abnormal biomechanics, anatomical variants, or both. Masses including tumors

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such as osteochondromas, elastofibroma dorsi, and rarely chondrosarcoma can be the cause and must be excluded.

Patients with scapulothoracic bursitis or SSS typically complain of pain and crepitus that is audible and/or palpable with scapular movement, particularly with overhead activities. Physical examination includes a visual inspection of posture as well as spinal abnormalities such as scoliosis or kyphosis. Dynamic evaluation of both scapulae is imperative to detect evidence of asymmetry, dyskinesis, winging, or audible snapping. Periscapular palpation may reveal areas of localized tenderness consistent with adventitial bursal inflammation. The superomedial angle followed by the inferomedial angle of the scapula are the most common locations for painful bursae. Muscle strength testing should be performed to identify any weakness that may result in biomechanical force imbalance, scapular dyskinesia or winging, and resultant snapping. Standard radiographs comprising of true anteroposterior, tangential Y, and axillary views should be obtained when a diagnosis of snapping scapula syndrome is considered to rule out mass lesions. Advanced imaging such as computed tomography (CT) and magnetic resonance imaging (MRI) can further characterize suspected lesions. MRI can further identify soft tissue structures that may be responsible for scapulothoracic crepitus such as scar tissue, inflamed tissue, or musculotendinous disease.

The principal treatment for scapulothoracic bursitis and SSS is nonoperative focusing on physical therapy for scapular stabilization and strengthening and also consists of activity modification, anti-inflammatories, and injections. For those patients who fail nonoperative treatment, particularly those patients who improve with injections or have identifiable anatomic lesions, surgery should be considered.

Operative Principle

For those patients who have persistent symptoms despite nonoperative treatment, scapulothoracic bursectomy aims to remove the pathologic tissue from the scapulothoracic articulation in order to decrease the pain and the mechanical crepitus with upper extremity function. For those patients with anatomic variants or mass lesions, surgery aims to similarly alleviate symptoms by restoring the congruency of the scapulothoracic articulation.

Indications

Scapulothoracic bursectomy is indicated in patients who have failed nonoperative treatment or in patients with an osseous or soft tissue mass that is causative of their symptoms. Surgery may provide more reliable results in patients who experience temporary relief with injections or in those patients with anatomic abnormalities contributing to their symptoms. In cases of bursitis or in the presence of smaller mass lesions, an arthroscopic technique is recommended; however, if malignancy is suspected or for larger mass lesions, appropriate preoperative workup by an orthopedic oncologist is recommended prior to any surgical intervention.

Contraindications

This procedure is contraindicated in patients without anatomic abnormalities who have not exhausted nonoperative treatment measures. Additionally, patients with mass lesions concerning for malignancy should undergo appropriate preoperative evaluation and workup by a musculoskeletal oncologist prior to operative intervention.

Technique

Assessment of the patient in the preoperative holding area is useful to identify and mark the most painful areas and maximize success of the procedure. Once in the operating room, the patient is subsequently positioned prone with the nonoperative arm tucked to the side and the posterior thorax draped widely. The operative extremity is placed into a sterile stockinet and then in the "chicken wing" position such that the dorsum of the operative hand is positioned on the lower back with the glenohumeral joint in extension and internal rotation (Fig. 24.1).

This position increases the potential space between the scapula and the chest wall. Placing a medially directed force on the lateral shoulder causes bayonet apposition of the scapular body and can increase this space further. The palpable bony landmarks of the medial border and the spine of the scapula are marked. Portals are made 3 cm medial to the medial scapular border and inferior to the scapular spine to decrease the risk of injury to the dorsal scapular nerve and artery and spinal accessory nerve (Fig. 24.2). Medial portal placement also allows a trajectory into the bursae that is parallel to the chest wall and decreases the risk of thoracic penetration.

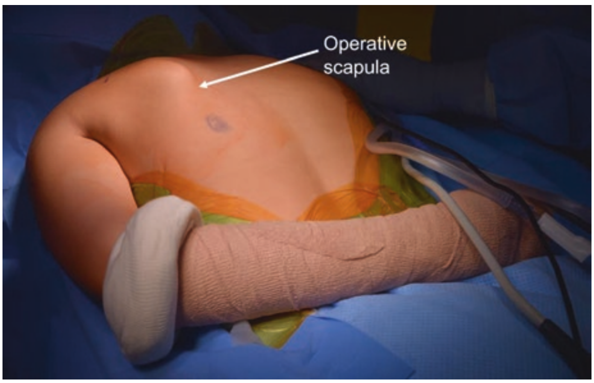

Fig. 24.1 The patient is positioned prone, and the left upper extremity is maximally internally rotated and extended at the glenohumeral joint to place in the dorsum of the hand on the lower back in the "chicken wing" position

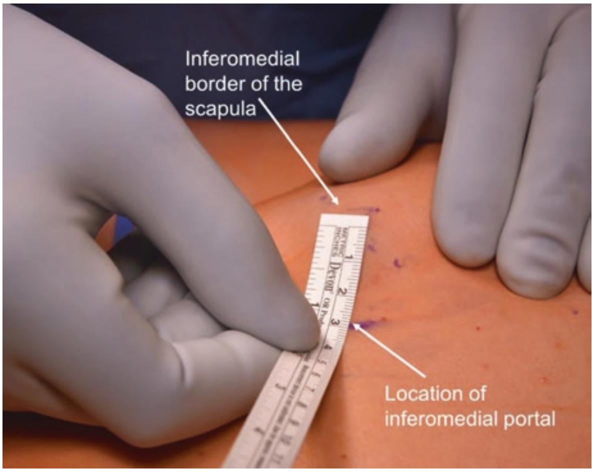

Fig. 24.2 The inferomedial portal is marked and demonstrated here 3 cm medial to inferomedial border of the scapula

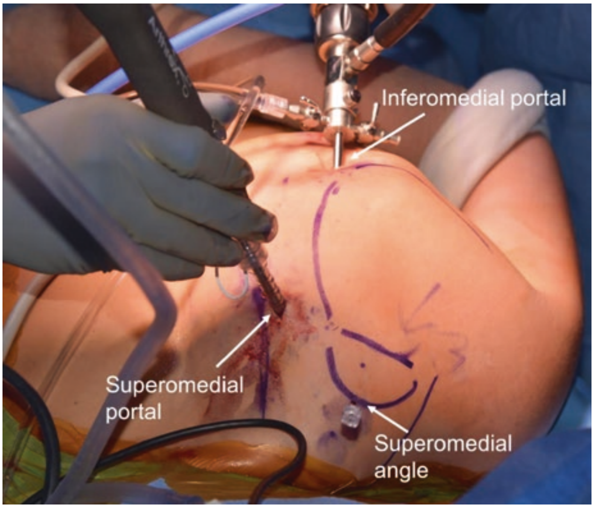

Fig. 24.3 The superomedial portal is demonstrated as the working portal with the camera in the inferomedial portal. Note the spinal needle at the superomedial angle of the scapula to serve as a landmark for orientation and bony resection

An initial viewing portal is made 3 cm medial to the inferomedial angle of the scapula, and the arthroscope is introduced. Fluid pressure is routinely maintained at or below 50 mmHg. A second medial portal is placed by triangulation 3 cm medial to the scapula inferior to the scapular spine. A diagnostic arthroscopy is then performed identifying the intercostal muscles and ribs inferiorly, the subscapularis laterally, and the rhomboid and levator muscles medially. A spinal needle is placed along the superomedial scapular border for additional orientation (Fig. 24.3). The locations of maximal tenderness and crepitus are examined arthroscopically, and a bursectomy is performed. Typically, the superomedial angle is the most common location for symptoms. In these cases, a shaver or radiofrequency ablator is used to clear bursal tissue and fibrous bands in order to skeletonize the superomedial scapular border. The underlying muscular attachments to the superomedial angle are then cleared with a radiofrequency probe. If crepitus or snapping of the scapula remains clinically evident after the bursal tissue resection, a partial scapuloplasty may be required (Fig. 24.4a–d). Spinal needles can be placed to mark the extent of the planned resection. The arthroscopic scapuloplasty is then performed with a high-speed burr. In the case of a prominent superomedial angle, a triangular section of the bone of approximately 2 cm (superior to inferior) by 3 cm (medial to lateral) is typically removed, although the appropriate extent of resection is judged arthroscopically by dynamic examination of the scapular motion. A superior accessory portal can be used to aid the resection of the superomedial scapula if needed. This portal should be made at the junction of the medial one-third and lateral two-thirds of the distance between the superomedial scapular angle and the lateral

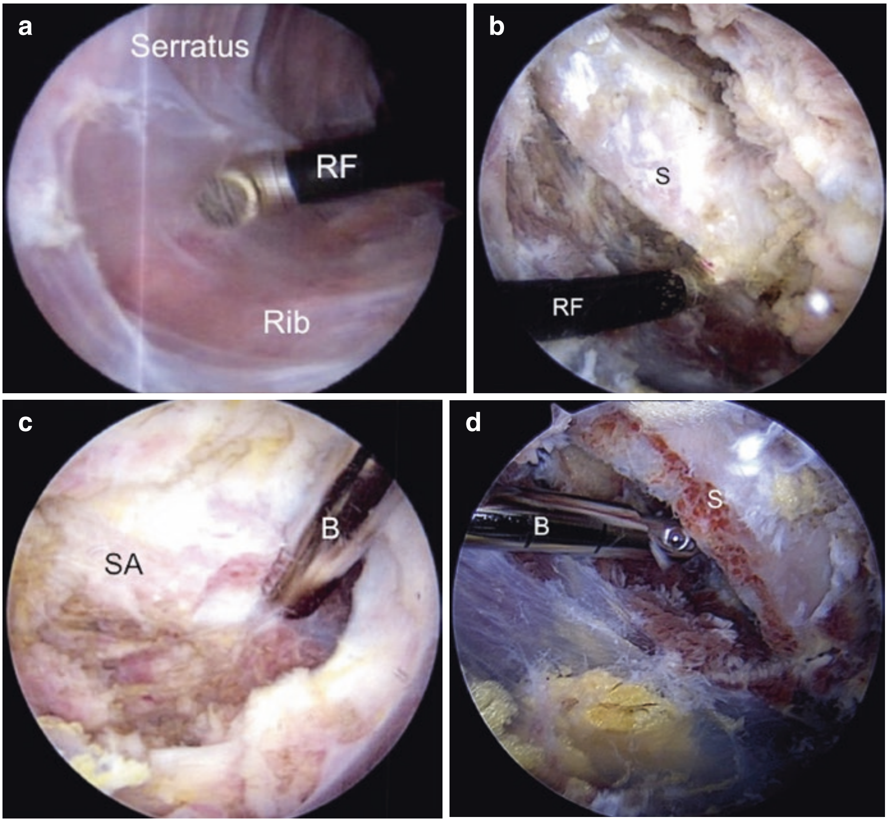

Fig. 24.4 Arthroscopic images. (**a**) A radiofrequency (RF) device removes inflamed bursal tissue in the scapulothoracic space. Cranial is the serratus anterior muscle (Serratus), caudal the ribs (Rib). (**b**) A radiofrequency (RF) device is used to resect further soft tissue to release the margin of the scapula (S). (**c**) After completion, the superomedial angle (SA) of the scapula is visible and is partially resected with a burr (B). (**d**) Final picture after resection of the superomedial angle of the scapula (S) with a burr (B)

acromion in order to protect the suprascapular nerve and artery. Following resection, a rasp can be used to contour the resected edges. Routine intraoperative examination ensures adequate clearance and that residual crepitus does not persist. Arthroscopic instruments should proceed no further than the spinal needle placed to mark the extent scapular resection as the suprascapular nerve can be at risk if this resection is taken too far laterally. Finally, portals are closed routinely, and a sling is applied postoperatively.

Pearls and Pitfalls

Surgical step	Pitfalls	Pearls
Preoperative evaluation	Failure to identify precise area of symptoms	Identify precise areas of pain and crepitus in order to optimize postsurgical outcome
Positioning	Suboptimal placement of the operative extremity leads to decreased potential space in the scapulothoracic articulation	Prone with operative extremity in the "chicken wing" position
Portal placement	Placing portals too medial or too proximal can endanger the dorsal scapular and spinal accessory nerves	Place portals 3 cm medial from medial scapular border and inferior to the spine of the scapula. The most inferior portal should be made proximal enough to visualize the superomedial angle of the scapula
Arthroscopic bursectomy	Visualization or resection of muscle fibers/tissue indicates that the arthroscopic instruments may not be in the scapulothoracic articulation	Bursal tissue should be resected in order to allow more adequate visualization and should be resected in the region that the patient indicated as painful preoperatively Red muscle fibers should not be resected
Partial scapuloplasty	Inadequate visualization of the superomedial angle of the scapula or mass lesion prevents adequate resection	Diligent removal of all soft tissue from the region of bony resection allows accurate resection with high-speed burr Routine intraoperative dynamic examination ensures adequate resection
Operative technique	Extensive swelling and extravasation of fluid into the soft tissues may occur with a prolonged procedure	The arthroscopic pump should be maintained at 50 mm hg or less The procedure should be performed efficiently in order to minimize extravasation of arthroscopic fluid into the tissues

Postoperative Management

Patients undergoing arthroscopic surgery have few limitations following surgery and a relatively quick recovery. They wear a sling for 1–2 days postoperatively and then begin both passive and active motion of the operative extremity as tolerated including scapular retraction and protraction. Physical therapy begins immediately postoperatively and focuses on thoracic posture, scapular coordination, and strengthening. Full active motion following the arthroscopic procedure is typically achieved by 1 week. Full recovery for participation in activities of daily living can be expected at 2–4 weeks postoperatively; however, return to sports and overhead athletic activities should be delayed 2 or 3 months to ensure optimal recovery.

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Pectoralis Major Repair

25

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Introduction/Background

The pectoralis major functions as one of the main sources of power for the upper extremity and achieves internal rotation, flexion, and adduction of the arm. The pectoralis major consists of the clavicular and the sternal heads, which are named based on the origins of these portions of the muscle with the clavicular head originating from the clavicle and the proximal sternum and the sternal head from the more distal sternum, the external oblique muscle, and the costal cartilage of ribs 1 through 6. Both heads insert on the humeral shaft lateral to the bicipital groove in a broad insertion of approximately 5 cm. The long head of biceps tendon courses deep to pectoralis major's tendinous fibers near its insertion. The clavicular head inserts anterior and superficial to the broader sternal head which rotates 180 degrees near its insertion on the humeral shaft to give the axillary fold its contour.

Pectoralis major ruptures typically occur in young and athletic patients, classically weight lifters, due to violent, eccentric contractions of the muscle. Common mechanisms include severe traction on the arm, forced abduction against resistance, or eccentric contraction during weightlifting. The sternal head is more commonly injured than the clavicular head, and injury typically occurs at or just proximal to the humeral insertion of the muscle. Due to their rarity, pectoralis major injuries are missed or misdiagnosed frequently.

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On clinical presentation, patients complain of severe pain to the anterior shoulder and may have a history of a “popping” sensation during a clearly identifiable incident of injury. On exam, they may have bruising in the anterior shoulder and axillary fold, asymmetric webbing of the axillary fold with a palpable defect, and weakness on resisted adduction and internal rotation of the affected extremity. Radiographs should be obtained if the diagnosis of pectoralis major injury is suspected to evaluate for a bony avulsion of the humeral insertion or other acute osseous injuries. Magnetic resonance imaging or ultrasound can evaluate the integrity of the tendon and localize the site of injury as well as differentiate between complete, partial, or intramuscular tears.

Treatment includes nonoperative and operative options with nonoperative treatment typically recommended for older or more sedentary patients, tears involving the proximal muscle belly or musculotendinous junction, and partial tears. Surgical treatment is recommended for active, healthy patients and for tears that are high-grade partial or complete, as these injuries will lead to weakness and a disfiguring defect if not repaired. The standard of care for healthy, active people who typically engage in activities that lead to pectoralis major injury is surgical treatment. Both acute and delayed repairs have shown superior outcomes than nonoperative treatment in these cases.

Operative Principle

Pectoralis major repair is recommended for active, healthy patients with high-grade partial or complete tears to restore the anatomy and function of the main power generator of the upper extremity. Through repair of this muscle and tendon, patients who suffer this injury can regain their strength and function at a high level, whereas nonoperative treatment in these cases leads to significant functional and strength deficits.

Indications

Surgical repair of the pectoralis major is indicated in healthy, active individuals with complete or high-grade partial tears involving the humeral insertion of the muscle. Both acute and chronic tears can be successfully addressed with surgery. Patients initially treated nonoperatively who find the results unsatisfactory are also candidates for surgical intervention.

Contraindications

Relative contraindications for pectoralis major repair include small partial tears, proximal muscle belly injuries, or injuries in severely low-demand patients with minimal upper extremity demands.

Technique

Anesthesia for this procedure includes an interscalene nerve block placed preoperatively to maximum muscle relaxation to facilitate surgical manipulation as well as control pain perioperatively. General anesthesia is also induced, and patients are positioned in the beach chair position. The operative upper extremity is draped free and placed in a pneumatic arm holder. The bony landmarks of the clavicle and coracoid are marked with indelible ink. A 6 cm modified deltopectoral incision is made with the proximal aspect of the incision starting more medially, just distal to the coracoid process, to facilitate retrieval of the retracted pectoralis major tendon and the distal extent of the incision extending more laterally in order to have access to the tendinous insertion on the humeral shaft. Dissection is then carried down through the subcutaneous tissues, and the anterior fascia of the pectoralis major tendon is identified along with the underlying clavicular head and sternal head. The clavicular head, which lies anterior to the sternal head, is commonly intact on the humeral shaft. In these cases, the intact clavicular head can be retracted proximally and laterally, and dissection distal and deep to the clavicular head often identifies the ruptured sternal head. The deltopectoral interval can also be utilized to identify the injured sternal head by retracting the cephalic vein and the deltoid proximally and working proximal to the clavicular head. Once the sternal head is clearly identified, traction sutures can be placed through the tendon to judge its excursion and mobility. Any adhesions preventing excursion of the torn pectoralis major tendon are released with blunt, digital dissection both superficial and deep to the muscle belly, although care should be taken to not dissect too deeply posteriorly to prevent injury to the medial and lateral pectoral nerves.

The native insertion of the pectoralis major tendon is then identified on the humeral shaft just lateral to the bicipital groove. A Bovie and a blunt elevator are used to elevate the periosteum and fully expose the insertion site, and a light decortication is performed to prepare the site for optimal tendon healing. At this point, a drill is utilized to make a unicortical hole in the anterior aspect of the humeral shaft in preparation for placement of a unicortical button. Two or three drill holes are placed depending on the size of the tear. The unicortical buttons are then loaded with nonabsorbable suture and placed into the intramedullary canal of the humeral shaft. The sutures are then whipstitched into the retracted tendon taking care to achieve suture fixation in the posterior aspect of the sternal head tendon which has a more robust fascia than the anterior aspect. Once all unicortical buttons have been placed and all sutures passed through the tendon stump, the sutures are tensioned and secured to bring the tendon stump down to its native footprint (Fig. 25.1). The repair is ideally performed with minimal tension with the shoulder in 30 degrees of abduction, 30 degrees of forward flexion, and 30 degrees of external rotation. Effort should be made to repair the native tendon in a fashion with minimal tension if at all possible, but if a tension-free repair cannot be achieved, an Achilles allograft can be used to augment the repair by sewing the tendon medially to the native tendon and then securing the allograft laterally to the humeral shaft insertion site. Even in most chronic tears, however, the native tendon can be adequately mobilized after a

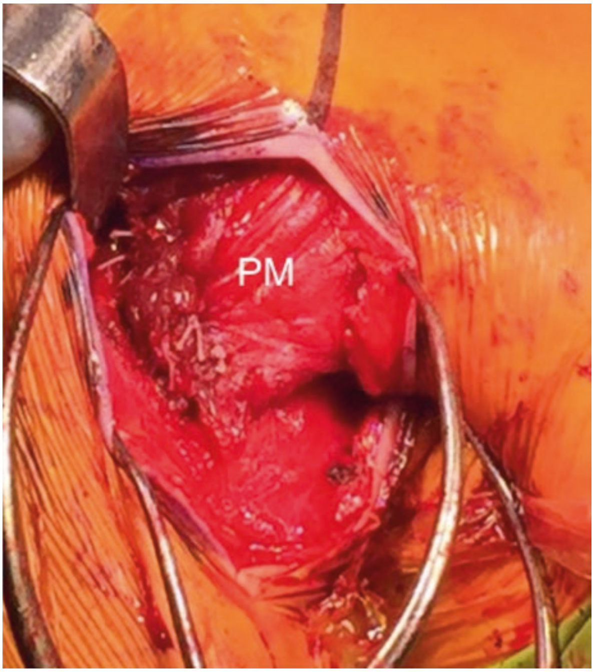

Fig. 25.1 Sternal head of pectoralis major after repair. Note that the clavicular head is being retracted proximally and laterally to illustrate the repair

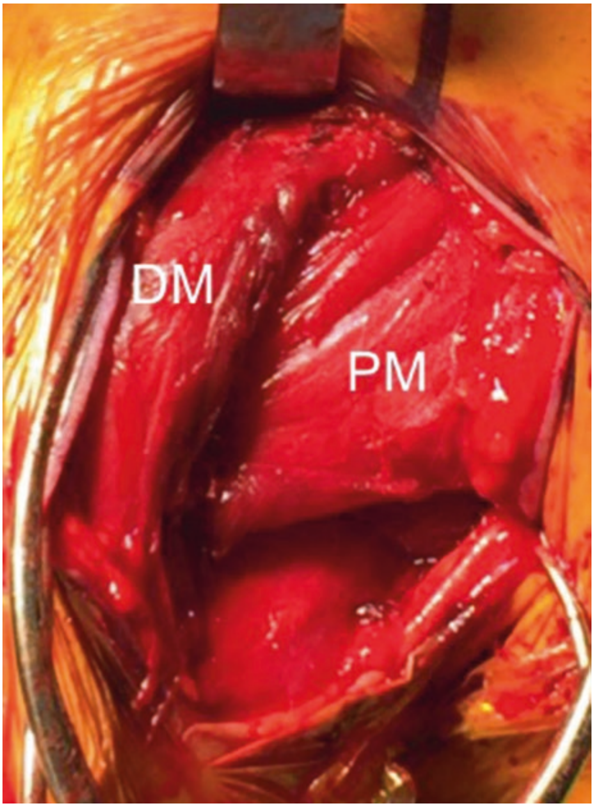

Fig. 25.2 Once the lateral retractor is released, the deltoid muscle covers the footprint of the pectoralis major tendon and hides the repair

Fig. 25.3 Postoperative radiograph of a right shoulder following *M. pectoralis* major repair. Three unicortical buttons were used to repair the torn tendon

meticulous dissection and clearance of adhesions. If a clavicular head tear is identified in addition to the sternal head tear, it is repaired in a similar fashion. Once the lateral retractor is released, the deltoid muscle covers the footprint of the pectoralis major tendon and hides the repair (Fig. 25.2). The surgical wound is then irrigated and closed in a standard fashion. A postoperative radiograph can be obtained to verify the optimal position of the inserted unicortical buttons (Fig. 25.3).

Pearls and Pitfalls

Surgical step	Pitfalls	Pearls
Incision	Making standard deltopectoral incision may make retrieval of retracted tendon difficult	Modified deltopectoral approach extending more medially proximally and more laterally distally facilitates tendon retrieval and humeral insertion preparation
Identification of sternal head	Sternal head may not be fully visualized initially if clavicular head remains intact	Dissection inferior to clavicular head and superior to clavicular head through the deltopectoral interval can facilitate sternal head exposure
Tendon mobilization	Inadequate dissection of adhesions can limit tendon excursion and prevent tension-free repair	Blunt, digital dissection both anterior and posterior to the retracted pectoralis major muscle belly can facilitate excursion and allow tension-free repair
Humeral preparation	Inadequate identification of native humeral insertion	The native humeral insertion is approximately 5 cm in length immediately lateral to the bicipital groove Unicortical drill holes should be placed appropriately (1 cm apart) to allow adequate bone bridge to prevent iatrogenic fracture

Surgical step	Pitfalls	Pearls
Tendon preparation	Not placing sutures through robust fascia	The most robust fascia on the sternal head is located at the posterior aspect of the tendon
Repair	Repairing the tendon under tension	The shoulder should be placed in 30 degrees of external rotation, abduction, and forward flexion during a repair Repair should be performed with minimal tension Achilles allograft augmentation can be used in cases in which the tendon cannot be fully mobilized to allow tension-free repair in the above position

Postoperative Management

Immediately postoperatively, external rotation is limited to 30 degrees and abduction to 90 degrees to protect the repair site. Range of motion without restriction is initiated at 4 weeks after surgery. Patients can begin strengthening at the 6-week point with anticipation of full return to activities without restriction by 4–6 months.

Recommended Literature

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2. Metzger PD, Bailey JR, Filler RD, et al. Pectoralis major muscle rupture repair: technique using unicortical buttons. Arthrosc Tech. 2012;1(1):e119–25.

Pectoralis Minor Tenotomy

26

George F. LeBus, Zaamin B. Hussain, Jonas Pogorzelski, and Peter J. Millett

Introduction/Background

The pectoralis minor originates from the third to fifth ribs and inserts on the superomedial border of the coracoid process. It plays a key role in the normal mechanics of the shoulder girdle due to its mediation of anterior tilt and internal rotation of the scapula. Physiologic function of the pectoralis minor muscle involves synchronous motion with the other muscles of the shoulder complex, and its role is important for optimal glenohumeral function. As such, the pathologic tightness or contracture of the pectoralis minor muscle that is characteristic of scapular dyskinesis and abnormal scapular protraction can cause significant dysfunction. This condition manifests clinically with limited range of motion and strength, anterosuperior shoulder pain, and a rounded posterior shoulder. Pectoralis minor tightness additionally may be a cause of subacromial impingement, particularly in overhead athletes as the tightened pectoralis minor muscle does not allow the subacromial space to adequately open during overhead activity. Causes of pathologic pectoralis minor tightness are varied but have been linked to overdevelopment of the pectoralis muscle due to repetitive overhead lifting or activities such as overhead sports.

While pectoralis minor contracture and tightness are common findings in patients with shoulder disorders in general and scapular dyskinesis in particular, most

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patients can be successfully treated with a targeted physical therapy protocol and stretching program to reestablish muscle length and elasticity. Some patients, however, may not respond to physical therapy and other nonoperative modalities. While the literature is limited regarding reports of isolated pectoralis minor release for this condition at this point in time, patients who fail conservative treatment may benefit from pectoralis minor tenotomy in conjunction with further physical therapy in order to reestablish appropriate scapular dynamics and improve the biomechanics of the shoulder girdle.

Operative Principle

For those patients who have persistent symptoms of scapular dyskinesis and pectoralis minor tightness despite nonoperative treatment, pectoralis tenotomy aims to resect the pectoralis minor tendon from the medial aspect of the coracoid process in order to decrease the force on the scapula causing pathologic anterior tilt and internal rotation and to allow the scapula to retract to improve scapular dynamics and overall glenohumeral function.

Indications

Pectoralis minor tenotomy may be indicated in patients who have been diagnosed with scapular dyskinesis in the form of abnormal scapular protraction and pectoralis minor tightness who have failed nonoperative treatment and who have no other neurologic or structural abnormality to explain their abnormal scapular biomechanics. These patients have limited overhead range of motion and strength and anterosuperior shoulder pain, often with tenderness over the pectoralis minor tendon itself.

Contraindications

This procedure should likely not be undertaken in patients with a neurologic component contributing to their scapular dysfunction (i.e., long thoracic nerve palsy), thoracic outlet syndrome, other glenohumeral abnormalities such as rotator cuff tear, labral pathology, or glenohumeral degenerative disease.

Technique

Although there are few reports of pectoralis minor tenotomy in the literature at this point in time, both mini-open and arthroscopic techniques have been described. The senior author prefers an arthroscopic technique. The patient is positioned in the beach chair position with operative arm positioned in a pneumatic arm holder. The operative extremity and shoulder are draped widely. The palpable bony landmarks of the acromion, the scapular spine, and the clavicle are marked as well as the coracoid process.

A standard initial posterior viewing portal is made approximately 2 cm medial and inferior to the posterosuperior angle of the acromion, and the arthroscope is introduced. A standard anterior portal is made in the rotator interval, and a diagnostic arthroscopy of the glenohumeral joint is performed. The subacromial space is similarly evaluated utilizing the posterior portal as the viewing portal and an additional anterolateral portal as the working portal. All other necessary components of the shoulder arthroscopy are performed prior to pectoralis minor tenotomy including subacromial bursectomy and decompression and any other indicated procedures.

At this point, attention is turned to the pectoralis minor tenotomy. The arthroscope is placed in the anterior portal such that the coracoid process is clearly visualized (Fig. 26.1). Placement of a switching stick through the anterolateral portal to tent open the subdeltoid space can allow more clear visualization and a larger working space anteriorly. An accessory anterior portal is subsequently established just lateral and superior to the coracoid process using a spinal needle for accurate localization. The trajectory of this portal should aim toward the pectoralis minor insertion on the coracoid process. The pectoralis minor tendon can be resected from the coracoid process utilizing an electrocautery device through the accessory anterior portal (Fig. 26.2). The pectoralis minor tendon should be tenotomized from superficial to deep in broad strokes (Fig. 26.3) in order to protect the underlying neurovascular structures (Fig. 26.4). Once the pectoralis minor is fully resected, the arthroscopic instruments are removed, and the portals are closed in routine fashion. A sling is applied postoperatively.

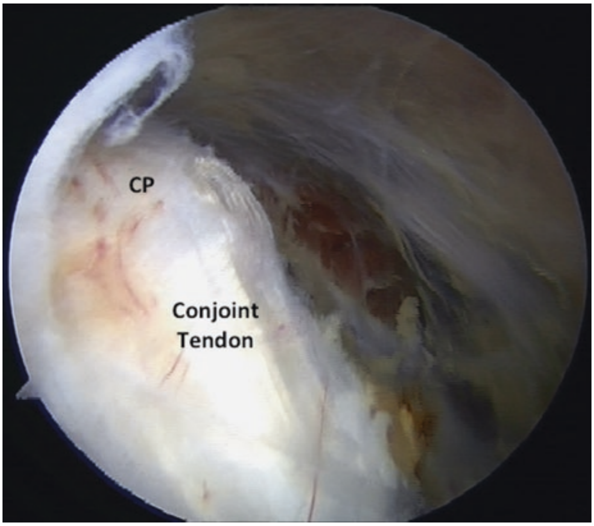

Fig. 26.1 Arthroscopic view through an anterior standard working portal of the coracoid process (CP) and the conjoint tendon

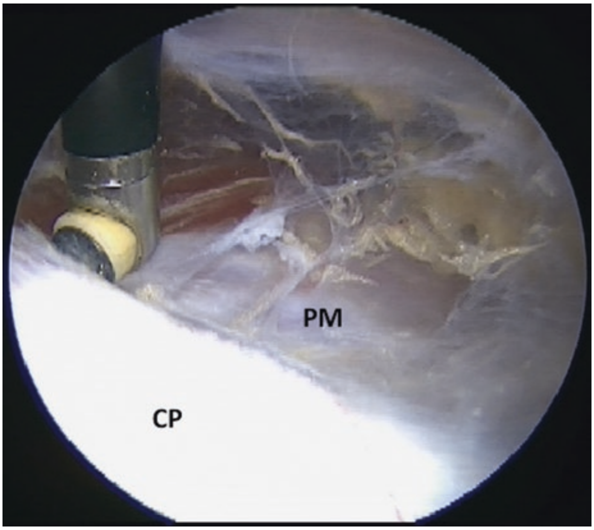

Fig. 26.2 The pectoralis minor (PM) tendon can be resected from the coracoid process (CP) utilizing an electrocautery device through an accessory anterior portal

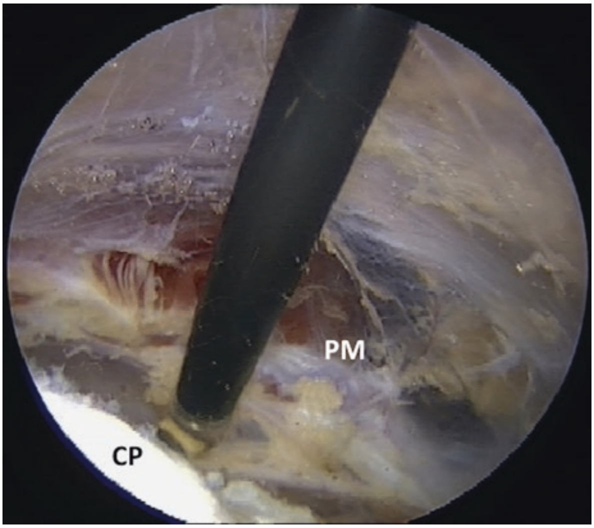

Fig. 26.3 The pectoralis minor (PM) tendon should be tenotomized from superficial to deep in broad strokes. CP coracoid process

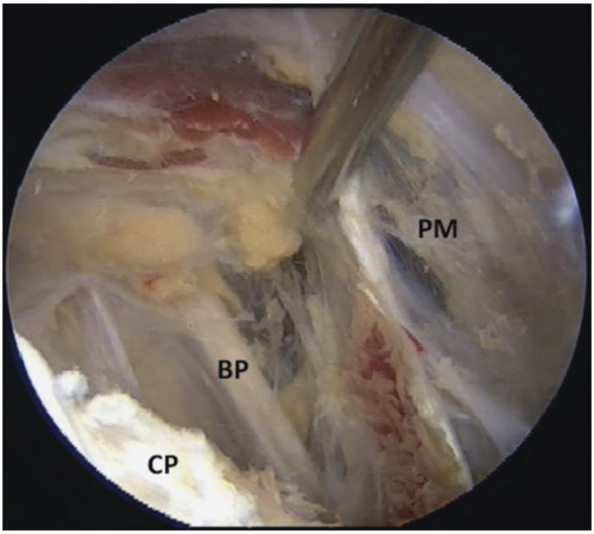

Fig. 26.4 Superficial to deep tenotomy helps protect the underlying neurovascular structures such as the brachial plexus (BP). CP coracoid process, PM pectoralis minor muscle

Pearls and Pitfalls

Surgical step	Pitfalls	Pearls
Preoperative evaluation	Failure to rule out other contributing factors to scapular dyskinesis such as nerve injury	Identify areas of point tenderness on exam such as over the pectoralis minor tendon insertion on the coracoid
Positioning	Draping too narrowly can limit access to the coracoid process	Use of a pneumatic arm holder aids intraoperative position and manipulation of the operative extremity
Anterior visualization	Failure to perform adequate subacromial bursectomy can limit visualization of the coracoid process and pectoralis minor tendon anteriorly	Utilize a switching stick or other blunt retractor through the anterolateral portal to tent open the deltoid in order to enlarge to anterior working space
Portal placement	An inadequately placed accessory anterior portal does not allow the appropriate angle to perform a pectoralis minor tenotomy	Utilize a spinal needle to create an accessory anterior portal just lateral and superior to the coracoid process The spinal needle will verify appropriate trajectory and ensure that pectoralis minor tenotomy can be performed through the portal
Pectoralis minor resection	Plunging during pectoralis minor resection should be avoided due to the underlying neurovascular structures medial to the coracoid process	Use of electrocautery and broad strokes working superficial to deep to perform pectoralis minor tenotomy will ensure complete resection and protect the underlying neurovascular structures

Postoperative Management

Patients who undergo arthroscopic pectoralis minor tenotomy have few limitations following surgery and begin full motion and rehabilitation immediately postoperatively. They wear a sling for 1–2 days and then begin full passive and active motion of the operative extremity as tolerated including scapular stabilization exercises and a pectoralis minor stretching program. Full active motion following the arthroscopic procedure is typically achieved by 1 week with recovery for participation in activities of daily living at 2–4 weeks postoperatively. Resolution of scapular dyskinesis and restoration of scapular dynamics with a guided physical therapy program can be expected at approximately 3 months with a full return to overhead activities and athletics at that time.

Recommended Literature

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