

Subacromial Space

M. Feucht, S. Baun

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2.1 Arthroscopic Subacromial Decompression (ASAD)

M. Feucht, S. Baun

2.1.1 Indication

Symptomatic outlet impingement (bony narrowing of the subacromial space by acromial spurs, Bigliani type II and III acromion morphology [■ Fig. 2.1], inferior AC joint osteophytes) after failure of conservative treatment trials or with concomitant rotator cuff lesions.

2.1.2 Operation Principle

Widening of the subacromial space and creating a flat inferior acromion surface by arthroscopic resection of the anteroinferior acromion with preservation of the coracoacromial ligament (■ Fig. 2.2). Optionally, concomitant resection of AC joint osteophytes (Coplaning).

2.1.3 Preoperative Assessment

Diagnosis

Clinical Evaluation

- Symptom-specific history: pain character (with load, at rest, at night), location and radiation of pain, previous infiltrations and operations.
- Symptom-specific examination: lower “painful arc” (60–120°), Neer sign, Hawkins-Kennedy sign and if applicable subacromial infiltration test.

Imaging (Radiographic Evaluation)

- X-rays of the shoulder in three views (true AP, y-view, axial) for evaluation of the acromion shape acromio-humeral distance and the undersurface of the AC joint (osteophytes)
- MRI scan to differentiate between intrinsic and extrinsic causes of impingement and to evaluate the rotator cuff tendons and other possible concomitant pathologies

Patient Information/Consent/Declaration

Specific operative risks: nerve injury (brachial plexus), injury of the subclavian artery, fracture of the acromion or clavicle

2.1.4 Operative Technique

Positioning and Preparation

- Beach chair position
- Positioning of the patient arm in arm holder

Arthroscopic Subacromial Decompression (ASAD)

A diagnostic arthroscopy and bursoscopy is performed through the standard posterior portal followed by partial subacromial bursectomy using a shaver or electrocautery probe introduced through the anterolateral working portal. The bony undersurface of the acromion is exposed with the shaver to visualize the entire anterior part of the acromion. The insertion of the coracoacromial ligament is released cautiously and sparingly with the electrocautery probe.

After clear visualization of the anterior and lateral margins of the acromion, a motorized bone shaver or burr is introduced through the anterolateral portal to begin resecting the bony undersurface of the anterior acromion edge. About half a shaver's diameter is removed, in a lateral to medial direction, till reaching the AC joint (■ Figs. 2.3 and 2.4a). Significant inferior osteophytes of the AC joint are removed as well, if necessary.

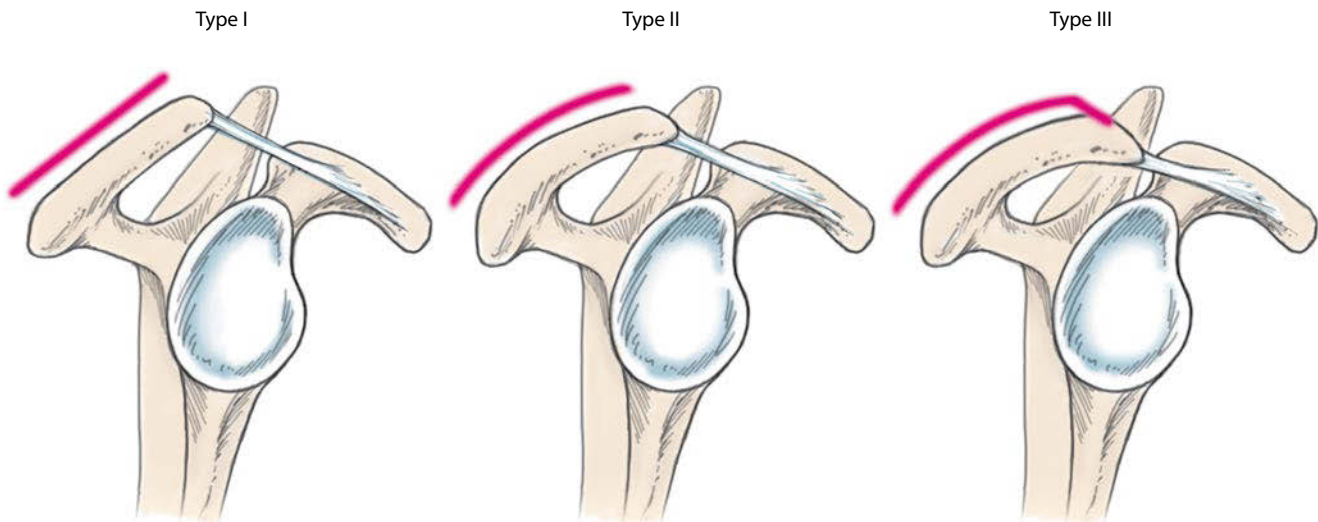
The arthroscope is switched to the anterolateral portal to check the amount of bone resected. As needed, resection can be completed, with the shaver brought in through the posterior portal. The goal should be a flat undersurface of the acromion (■ Fig. 2.4b). There is merely much bone to be resected to convert a Bigliani type II or III acromion into a Type I. Finally, hemostasis and denervation of the raw bone surface is performed with an electrocautery probe.

2.1.5 Postoperative Management

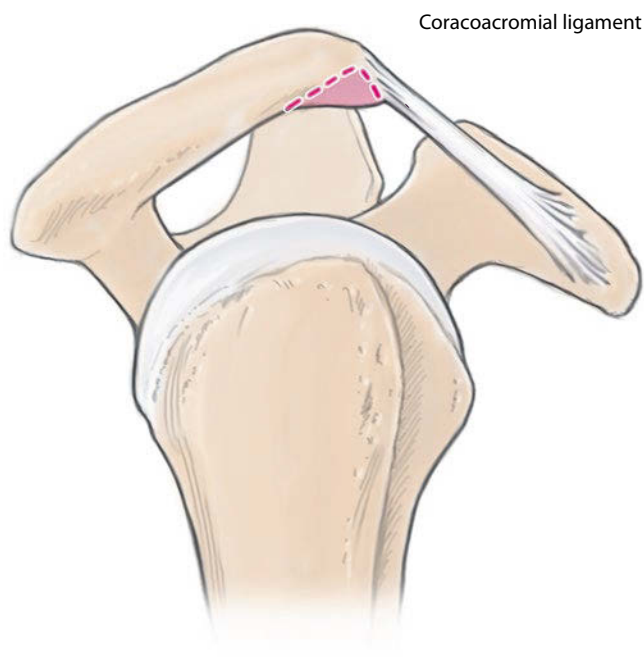
- Positioning of the arm in an arm sling
- Monitoring of peripheral circulation, motor and sensory innervations.
- Postoperative X-Ray evaluation.

2.1.6 Follow-Up Management

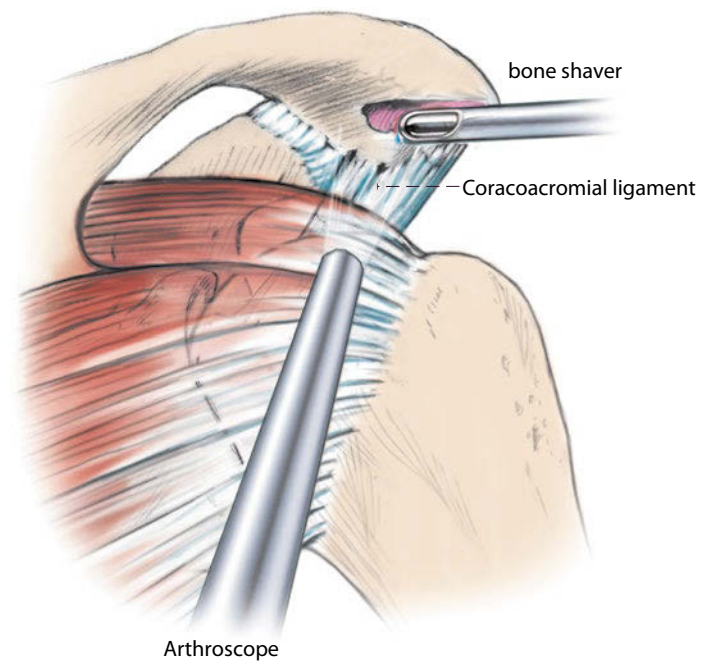
Immobilization of the shoulder in a sling for 24 h which is then only used at night and with prolonged activities for further 3 weeks. Abduction and flexion should be limited to 90° in the first 4 weeks, free range of motion is allowed from the 5th week.



■ Fig. 2.1 Different types of acromion morphology according to Bigliani



■ Fig. 2.2 The aim of the operation is a flat inferior surface of the acromion by resection of the anteroinferior acromion with preservation of the coracoacromial ligament



■ Fig. 2.3 Resection of the anteroinferior acromion edge with a bone shaver

2.1.7 Tips & Tricks

To ensure adequate resection of the anteroinferior acromion, the margins have to be clearly visualized. For easier arthroscopic orientation, the anterior margin can be marked with 2 needles. One needle is introduced along the margin of the anterolateral edge of the acromion towards the subacromial space and the second one is placed at the medial edge of the coracoacromial ligament just anterior to the AC joint.

To avoid bleeding from the thoracoacromial artery, the exposure of the anterior acromion margin should be done carefully with the use of electrothermal probe.

Care should be taken with complete resection of the coracoacromial ligament to avoid subsequent anterosuperior instability of the humeral head.

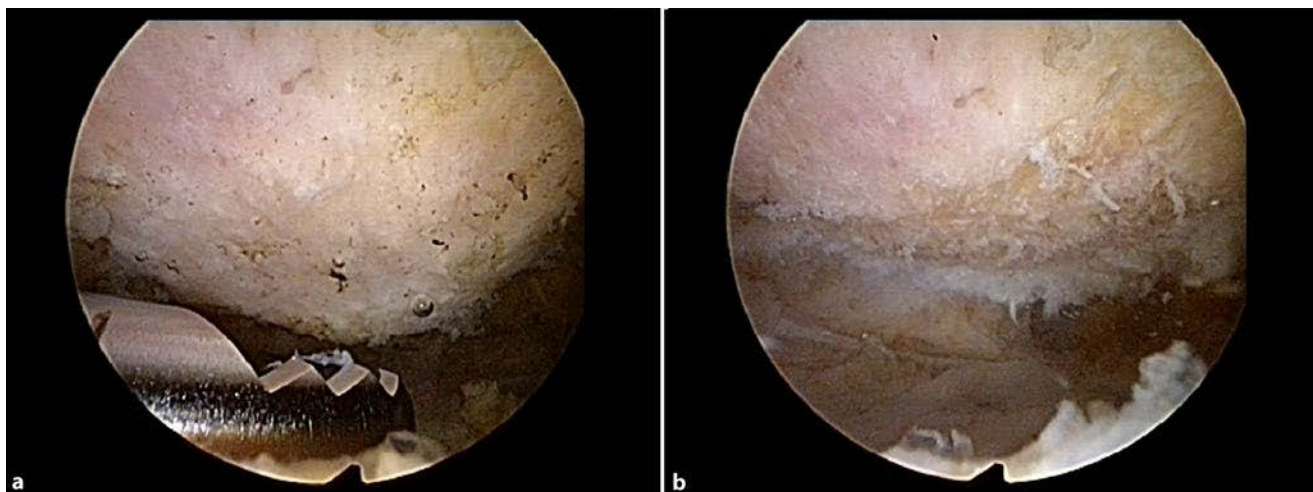


Fig. 2.4a,b Arthroscopic subacromial decompression. **a** Resection of the anteroinferior acromion edge with a bone shaver, **b** Final result with flat undersurface of the acromion



Fig. 2.5a–c Arthroscopic AC Joint resection. **a** Removal of the remnants of the intraarticular disc with the electrothermal device. **b** Bone resection with a bone shaver. **c** Denervation of the acromial and clavicular sides of the joint as well as the capsular insertion sites with the electrothermal device

2.2 Arthroscopic Resection of AC joint (ARAC)

M. Feucht, S. Braun

2.2.1 Indication

- Symptomatic osteoarthritis of the AC joint after failure of initial trial of conservative therapy
- Symptomatic outlet impingement due to inferior AC joint osteophytes/spurs.

2.2.2 Operation Principle

Arthroscopic resection of osteoarthritic surfaces of the AC joint with preservation of the stabilizing posterior and superior parts of the joint capsule.

2.2.3 Preoperative Assessment

Diagnosis

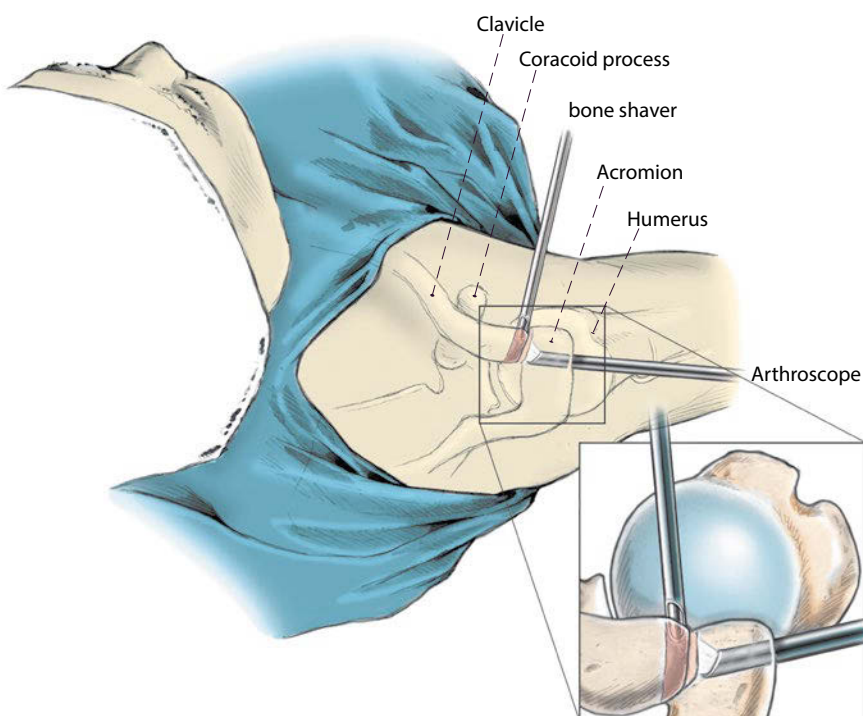
Clinical

- Symptom-specific history: previous injuries, previous infiltrations and operations, movement patterns related to occupation and sport with particular stress (e.g. Bench press), pain localization and radiation.
- Symptom-specific examination: localized tenderness over the AC joint, superior/high “painful arc” (pain after approx. 120° of abduction), “Cross-body adduction” test, evaluation of the stability of the AC joint, exclusion of concomitant cervical spine disease, Infiltration test.

Imaging

- X-rays of the shoulder in three views (true AP, Y-view, axial) as standard imaging modality and if necessary, additional Zanca-view for detailed evaluation of the AC Joint.
- MRI scan to assess the degree and activity of osteoarthritis and to exclude possible concomitant pathologies (e.g. partial rupture of the supraspinatus tendon secondary to outlet impingement)

Fig. 2.6 Resection of about 3–5 mm of the lateral end of the clavicle (diameter of the shaver blade) with a bone shaver and about 1–2 mm of the acromial side of the joint through the anterosuperior portal. The arthroscope is placed in the lateral portal



Patient information/Consent

Specific operative risks: nerve injury (brachial plexus), injury of the subclavian artery, AC joint instability.

2.2.4 Operative Technique

Positioning and Preparation

- Beach chair position
- Positioning of the patient arm in an arm holder

Arthroscopic Resection of the Acromioclavicular Joint

Diagnostic arthroscopy and bursoscopy is performed through the standard posterior portal followed by partial subacromial bursectomy using motorized shaver or electrocautery probe through a lateral working portal. The arthroscope is switched to the lateral portal and an anterosuperior working portal is established directly anterior to the AC joint in outside-in technique. Resection of the anterior and inferior joint capsule as well as any remnants of the articular disc with the electrocautery probe (**Fig. 2.5a**) exposing both clavicular and acromial articular sides of the joint.

About 3–5 mm of the lateral end of the clavicle (approx. one shaver's diameter) is removed with a bone shaver or bur introduced through the anterosuperior portal, beginning the resection anterolaterally and progressing posteriorly and superiorly with preservation of the posterior and superior parts of the joint capsule (**Figs. 2.6 and 2.5b**). This is followed by resection of about 1–2 mm of the acromial side of the AC

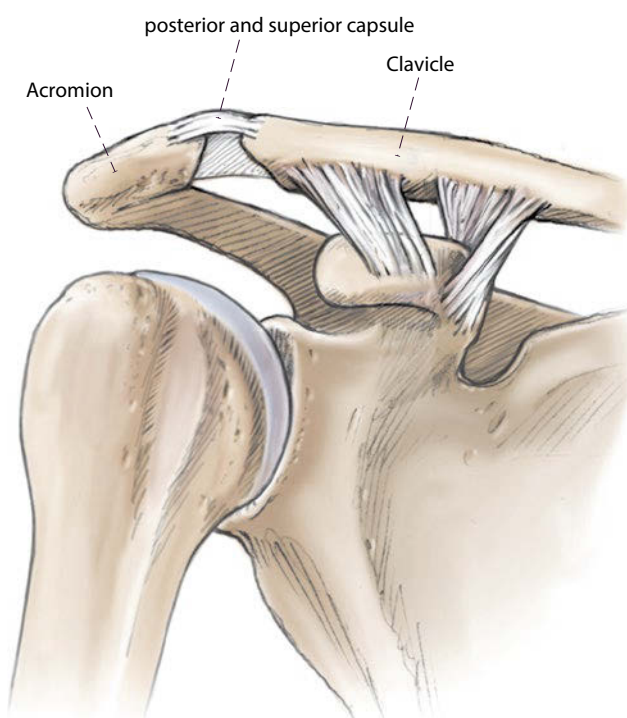


Fig. 2.7 The goal to be achieved is a domeshaped widening of the joint space with preservation of the superior and posterior parts of the joint capsule



Fig. 2.8 Easier intraoperative orientation with placement of two transarticular needles

joint. The goal to be achieved is a dome-shaped widening of the joint space (■ Fig. 2.7).

Finally, the raw acromial and clavicular bone surfaces as well as the insertion site of the resected capsule are denervated and coagulated with the electrocautery probe. The arthroscope is switched to the anterosuperior portal to check the extent of resection both statically and dynamically (through horizontal adduction movement (■ Fig. 2.5c).

2.2.5 Postoperative Management

- Positioning of the arm in an arm sling
- Monitoring of peripheral circulation, motor and sensory innervation
- Postoperative X-ray evaluation.

2.2.6 Follow-Up Management

Immobilization of the shoulder in a sling for 24h, which is used for the subsequent 3 weeks only at night and with prolonged activities. Horizontal adduction should be avoided for 6 weeks postoperatively. Abduction and flexion should be limited to 60° in the 1.–2. weeks with free rotation, then gradual increase of abduction and flexion to 90° from the 3rd to the 6th weeks. Free range of motion is allowed starting from 7th week.

2.2.7 Tips & Tricks

During resection, the superior and posterior parts of the AC joint capsule should be preserved to maintain the stability of the joint.

The goal of the procedure is a dome-shaped widening of the joint space to about 5 mm (approx. diameter of a shaver blade) with maintenance of the posterior and superior capsule.

A downward pressure on the clavicle or marking the joint with 2 needles introduced intraarticularly into the subacromial space can help to improve visualization of the AC joint and subsequently a better arthroscopic orientation during exposure and resection (■ Fig. 2.8).

Repeated switching of the arthroscope into the anterosuperior portal is recommended for better visualization of resected space and hence to ensure a complete resection of the articular surfaces.

2.3 AC joint Stabilization (Acute)

M. Feucht, S. Braun

2.3.1 Indication

Acute AC joint dislocation (within 2–3 weeks after injury), Rockwood type IV–VI, and Type III dislocation with posterior instability component as well as in patients with high functional demands.

2.3.2 Operation Principle

Arthroscopically assisted anatomical reconstruction of the coracoclavicular ligaments (conoid and trapezoid ligaments) using two transclavicular and transcoracoidal passed flip button pulley system (e.g. AC-TightRope system, Arthrex).

2.3.3 Preoperative Assessment

Diagnosis

Clinical

- Symptom-specific history: mechanism and time of the injury, individual functional demands (sports, work)
- Symptom-specific examination: inspection for bruises or abrasions, degree of elevation of the clavicle, piano key sign test, evaluation of the horizontal displacement of the clavicle as well as reducibility of the AC joint.

Imaging

- X-rays of the shoulder in three views (true AP, Y-view, axial view) to exclude fractures and to classify the injury, additional Zanca-view if needed for detailed evaluation of the AC joint.
- Optional MRI scan to exclude associated injuries (e.g., SLAP lesions, rotator cuff lesions)

Patient information/Consent

Specific operative risks: nerve injury (brachial plexus), injury of the subclavian artery, fracture of the clavicle or coracoid, pneumothorax, hemothorax, implant failure with recurrent instability, the potential need for open reduction or even switching to an alternative method (e.g., hook plate)

2.3.4 Operative Technique

Positioning and Preparation

- Beach-chair position
- Examination under anesthesia (displacement and reducibility of the ACG)
- Positioning of the patient's arm in an arm holder
- Marking the clavicular footprints of the coracoclavicular ligaments (conoid ligament 4.5 cm and trapezoid ligament 2.5 cm medial to the lateral end of the clavicle) and the mini-open-incision between these two points (■ Fig. 2.9)

Arthroscopically Assisted AC Joint Stabilization Using Two Flip Button Pulley Systems.

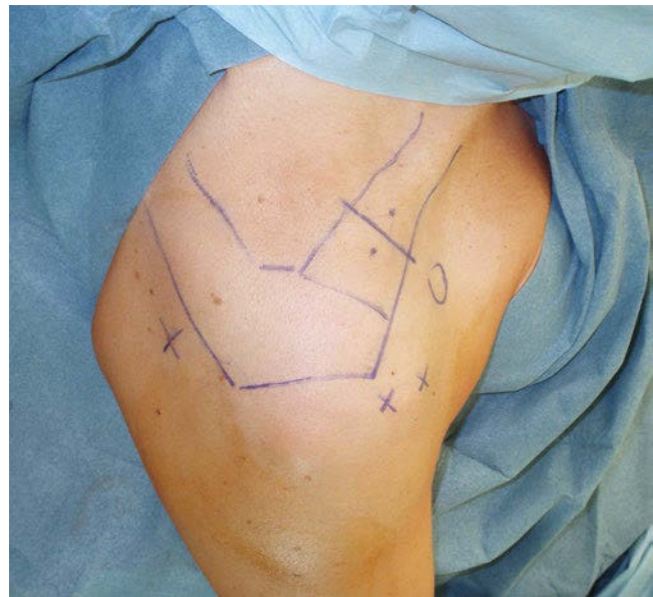
A diagnostic arthroscopy is performed through standard posterior portal to exclude intraarticular associated injuries followed by establishing a working anterosuperior portal as well as a second viewing anterolateral portal for better visualization of the coracoid base.

Soft tissues along the superior border of the subscapularis tendon are released until reaching the undersurface of the coracoid with an electrocautery probe introduced through the anterosuperior working portal. The arthroscope is switched to the anterolateral viewing portal to complete soft tissue release meticulously and thus exposing clearly the undersurface and the anteromedial edge of the coracoid (■ Fig. 2.15a).

The skin is incised, about 2–3 cm in length, perpendicular to the clavicle between the marked two clavicular foot prints, followed by incision of the deltotrapezial fascia along the line of trapezius muscle fibers to expose the clavicle.

The AC joint is anatomically reduced with the help of the arm holder and the reduction is checked with image intensifier before drilling the bone tunnels. Optionally, the arthroscope can be used to check the reduction from the subacromial space. A temporary fixation of the AC joint with K-wire can be performed if there is a difficulty to attain or maintain reduction.

A drill guide (e.g. AC Guide, Arthrex) is introduced through the anterosuperior working portal and the tip of its coracoid drill stop is placed on the undersurface of the coracoid at the appropriate anatomical location of the ligaments (conoid ligament drill hole: at the base of the coracoid, 5 mm lateral to the medial edge; trapezoid ligament drill hole: 10 mm anterior to the previous tunnel, 5 mm medial to the lateral edge) (■ Fig. 2.15b).



■ Fig. 2.9 Landmarks and approaches

Two 2.4-mm- guide pins are inserted transclavicular and transcoracoidal through the guide pin sleeve (■ Fig. 2.10). After checking the correct position of the pins, they are successively over drilled with cannulated 4-mm diameter drill bits, which are left in place after removal of the pins. There should be at least 12 mm bony bridge between the two guide pins.

A nitinol suture lasso is then passed through the cannulated drill in the conoid ligament tunnel (■ Figs. 2.11 and 2.15c) and withdrawn through the anterosuperior working portal with a grasper, followed by removal of the drill.

The Flip button pulley system (e.g. AC TightRope, Arthrex) is pulled under direct arthroscopic visualization from above downwards until the inferior button exits the inferior end of the coracoid tunnel (■ Fig. 2.12). The inferior button is then flipped under arthroscopic visualization and pulled proximally. The same sequence is repeated for the second Flip button (through trapezoid ligament tunnel).

The anatomical reduction of the AC joint is then checked radiologically (■ Fig. 2.13), followed by tightening and securing the sutures over the clavicular button with at least 5 knots with reversing the posts, starting with the medial system, representing the conoid ligament (■ Figs. 2.14 and 2.15d).

2.3.5 Postoperative Management

- Positioning of the arm in an arm sling
- Monitoring of peripheral circulation, motor and sensory innervations.
- Postoperative X-ray evaluation (■ Fig. 2.16)

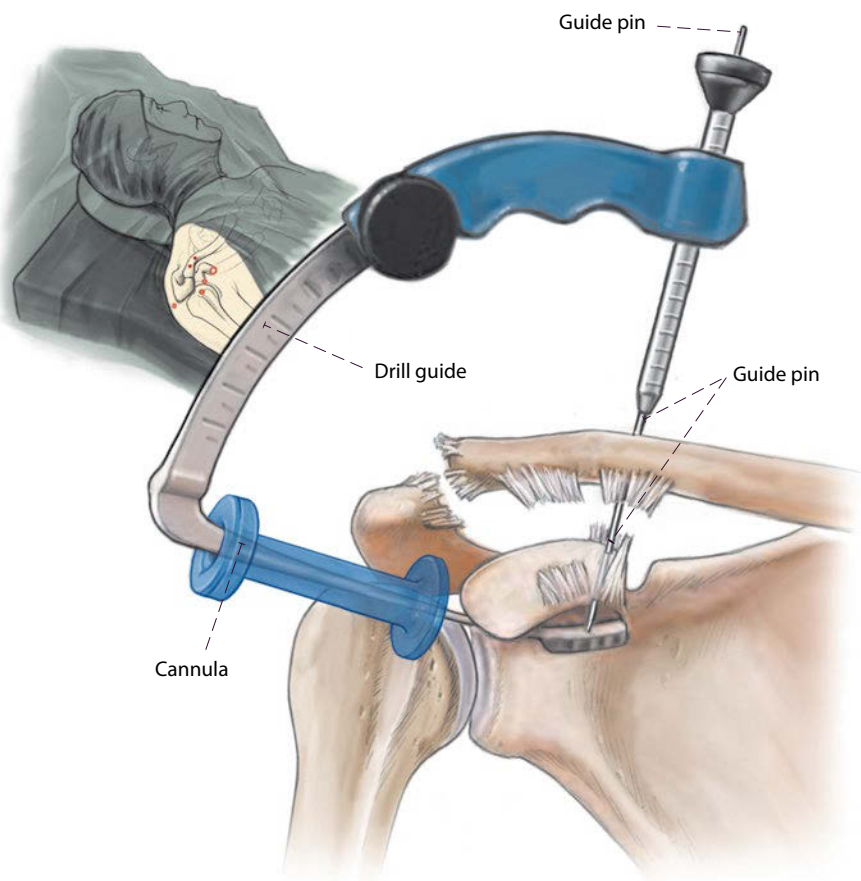


Fig. 2.10 Placement of the first guide pin through the aiming device (e.g. AC Guide, Arthrex)

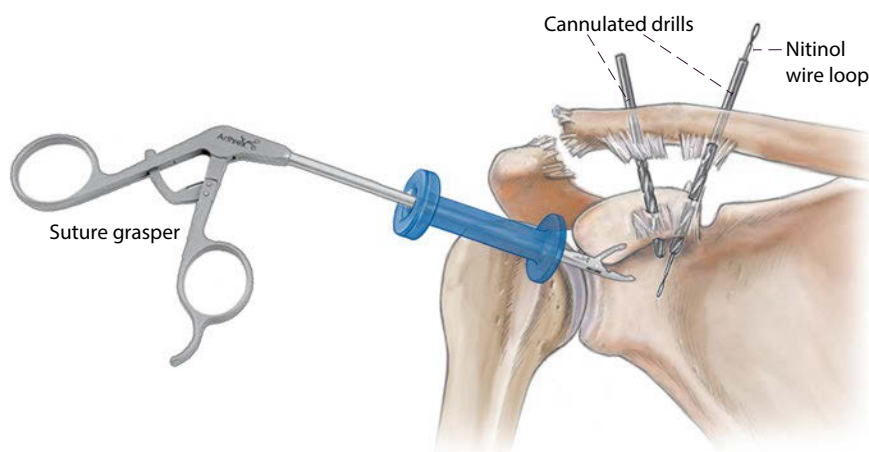


Fig. 2.11 Passing a nitinol suture lasso through the cannulated drill and withdrawing it through the anterosuperior working portal

2.3.6 Follow-Up Management

Immobilization in an arm sling for 6 weeks. The range of motion should be limited during physiotherapy and rehabilitation as follows:

- 1.–2. weeks passive: 30° abduction, 30° flexion, 80° internal rotation, 0° external rotation
- 3.–4. weeks active-assisted: 45° abduction, 45° flexion, 80° internal rotation, 0° external rotation
- 5.–6. weeks active: 60° abduction, 60° flexion, free internal and external rotation

- After the 7th postoperative week, free movements and after 3 months full load bearing are allowed.

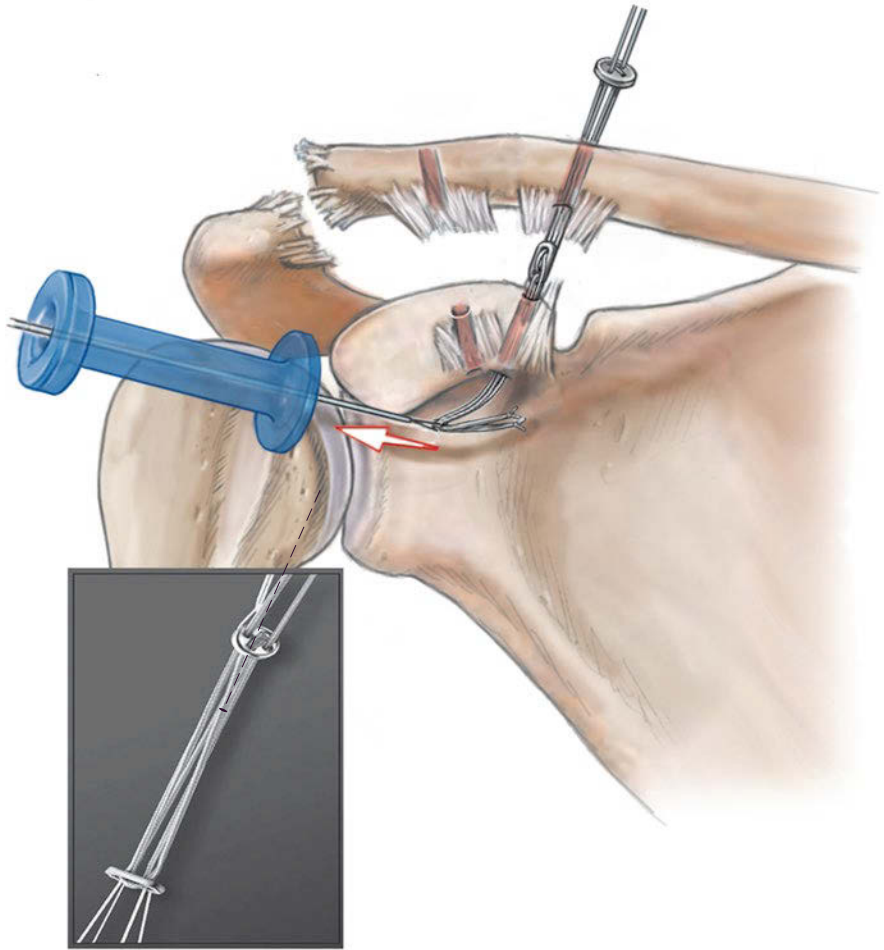
2.3.7 Tips & Tricks

The patient head should be tilted about 20° to the opposite side during positioning to have a sufficient space for placement and drilling of the bone tunnels.

A careful release of the coracoid undersurface with complete exposure of the entire base as well as the medial and

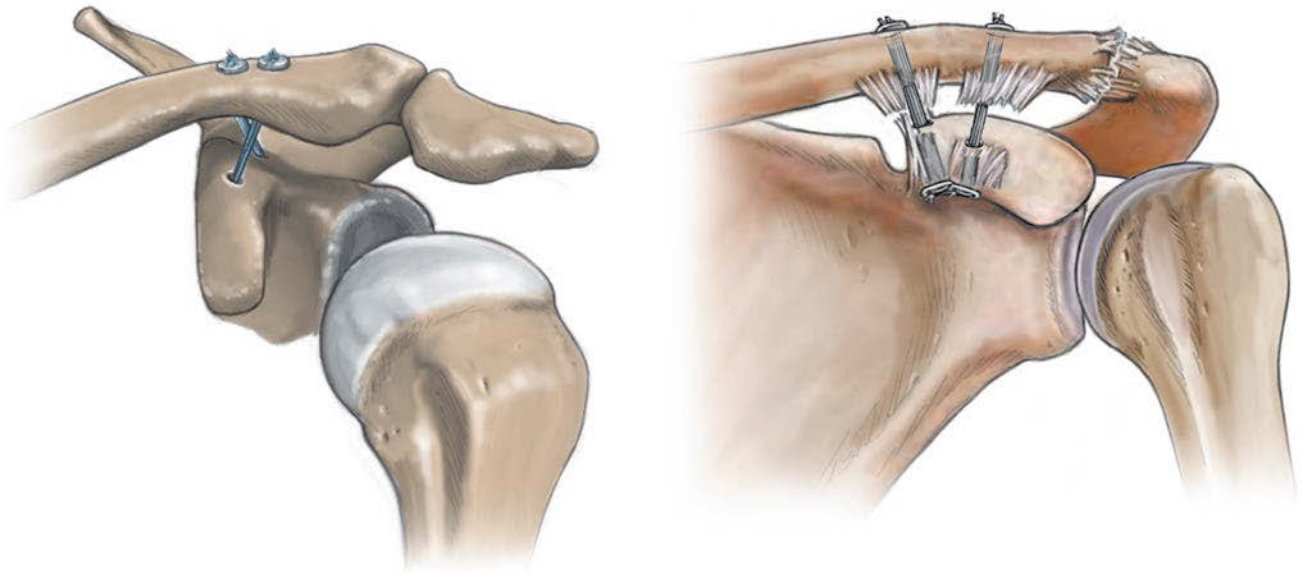
2.3 • AC joint Stabilization (Acute)

■ Fig. 2.12 Pulling the first Flip button system

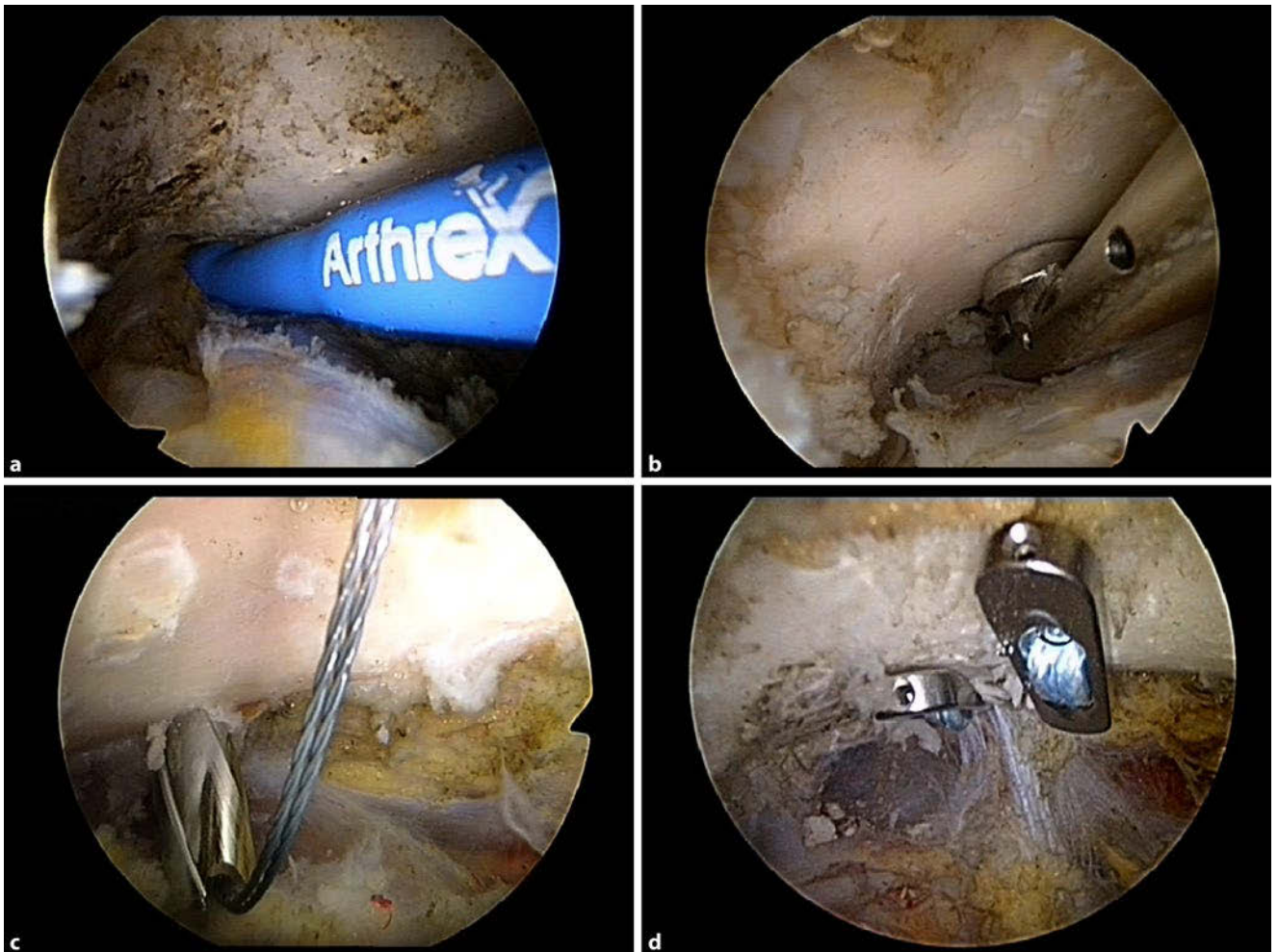


■ Fig. 2.13 Radiologically controlled reduction of the AC joint





■ Fig. 2.14 Final AC joint-stabilisation with two Flip button pulley system



■ Fig. 2.15a–d Arthroscopically assisted ACJ stabilization. a Exposure of the undersurface of the coracoid, b Placement of the guide hook under the coracoid. c Passing a Nitinol Suture lasso through a cannulated drill, d Final result



Fig. 2.16 Postoperative X-ray image after AC joint-Stabilization with two Flip button systems

lateral margin is crucial to ensure optimal positioning of the drill tunnels through the coracoid. Exposure of the tip of the coracoid is not needed.

Anatomical reduction of the AC joint should be carried out with the help of an arm holder under radiological control before introducing the drill guide and drilling the bone tunnels. The reduction should be checked again and corrected if necessary before tightening and securing the sutures (■ Fig. 2.10). Open reduction must be performed if closed reduction is not possible (e.g. due to soft tissue interposition).

For precise placement of the clavicular drill tunnels in the center of the clavicle, the anterior and posterior margins of the clavicle should be clearly visualized through insertion of 2 Hohmann retractors.

The placement of the guide wires as well as drilling the tunnels can be optionally performed under radiological control with an image intensifier.

Some authors recommend an additional acromioclavicular stabilization (e.g. with acromioclavicular cerclage) if there is marked horizontal AC joint instability.

2.4 AC joint Stabilization (Chronic)

M. Feucht, S. Braun

2.4.1 Indication

Chronic (> 3 weeks old), symptomatic Rockwood type III–VI AC joint dislocation.

Revision procedure after failed primary AC joint stabilization.

2.4.2 Operation Principle

Arthroscopically assisted anatomical reconstruction of both coracoclavicular ligaments using a Flip button pulley system (e.g. AC TightRope, from Arthrex) passed through the clavicle and coracoid in the course of the conoid ligament in addition to biological augmentation with autologous gracilis tendon graft passed in the course of the trapezoid ligament and looped around the coracoid and the clavicle in a modified figure of eight manner.

2.4.3 Preoperative Assessment

Diagnostics

Clinical Examination

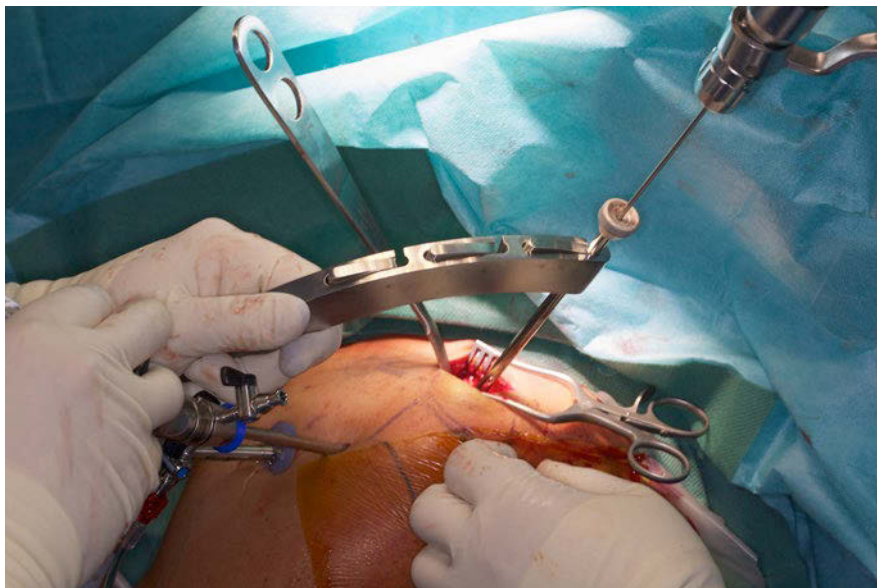
- Symptom specific history: mechanism and time of injury, individual functional demands (sports, work), type and number of previous surgeries (if any), previous knee surgeries (harvesting of tendons)
- Symptom specific examination: degree of upward displacement of the clavicle, piano key sign, evaluation of the horizontal displacement of the clavicle and reducibility of the AC joint.

Imaging

- X-rays of the shoulder in three views (true AP, y-view, axial), optionally, an additional Zanca-view for detailed evaluation of the AC joint as well as panorama view of both shoulders with axial load of 5 kg on each side.
- Optionally, MRI scan to exclude possible associated injuries (e.g., SLAP lesions, rotator cuff lesions)
- CT scan for evaluation of the bony status of both clavicle and coracoid in case of revision surgery.

Patient Information/Consent

Specific operative risks: nerve injury (brachial plexus), injury of the subclavian artery, clavicle or coracoid fracture, pneumothorax, hemothorax, implant failure with recurrent instability, probability of open reduction (if required) or even switching to an alternative method of fixation. (e.g. hook



■ Fig. 2.17 Arthroscopic assisted placement of the guide pins

plate). Potential morbidity after harvesting gracilis tendon (Injury of saphenous nerve).

2.4.4 Operative Technique

Positioning and Preparation

- Beach-chair position. The ipsilateral knee is draped with placement of a thigh tourniquet.
- Examination under anesthesia (displacement and reducibility of the AC joint)
- Positioning of the patient's arm in a arm holder.
- Marking the clavicular footprints of the coracoclavicular ligaments (conoid ligament 4.5 cm and trapezoid ligament 2.5 cm medial to the lateral end of the clavicle) as well as the mini- open-incision midway between these two points.

Arthroscopic Assisted ACJ Stabilization Using a Flip Button Pulley System and Gracilis Tendon Graft Augmentation.

The gracilis tendon graft is harvested and prepared as described in ► Sect. 13.1. A diagnostic arthroscopy is performed through the standard posterior portal to exclude intraarticular associated injuries. An anterosuperior working portal as well as a second viewing anterolateral portal are established in outside in technique for better visualization of the coracoids base.

The soft tissue along the superior border of the subscapularis tendon is released until reaching the undersurface of the coracoid process with an electrocautery probe introduced through the anterosuperior working portal. The arthroscope is then switched to the anterolateral viewing portal to complete soft tissue release meticulously and thus exposing

clearly the undersurface and the anteromedial edge of the coracoid.

A 2–3 cm long skin incision is made perpendicular to the clavicle between the marked two clavicular footprints followed by incision of the deltotrapezial fascia along the line of trapezius muscle fibers to expose the clavicle.

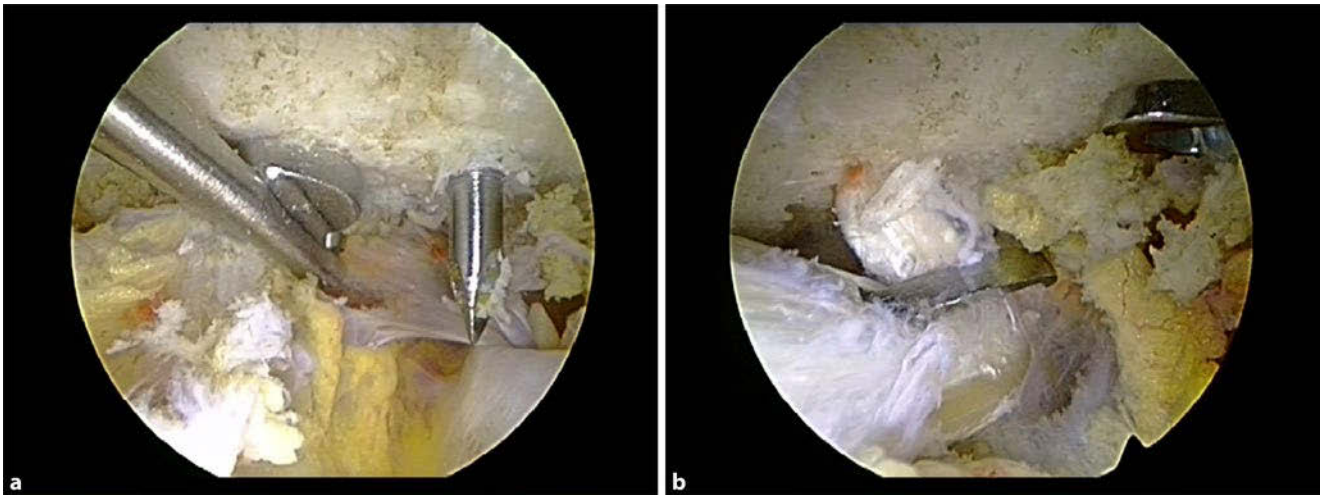
The ACJ is anatomically reduced with the help of the pneumatic arm holder and the reduction is checked with image intensifier before drilling the bone tunnels. Optionally, the arthroscope can be used to check the reduction from the subacromial space. A temporary fixation of the AC joint with K-wire can be performed if there is a difficulty to attain or maintain reduction.

A drill guide (e.g. AC Guide, Arthrex) is introduced through the anterosuperior working portal and the tip of its coracoid drill stop is placed on the undersurface of the coracoid at the appropriate anatomical location of the ligaments (conoid ligament drill hole: at the base of the coracoid, 5 mm lateral to the medial edge; trapezoid ligament drill hole: 10 mm anterior to the previous tunnel, 5 mm medial to the lateral edge) (■ Fig. 2.15b).

Two 2.4-mm-guide pins are inserted transclavicular and transcoracoidal through the guide pin sleeve (■ Figs. 2.17 and 2.18a).

After checking the correct position of the guide pins, the pin in the course of the conoid ligament is over-drilled with a cannulated 4-mm diameter drill bit, which is left in place after removal of the pin. A Nitinol Suture lasso is then passed through the cannulated drill and withdrawn through the anterosuperior working portal with a suture grasper followed by removal of the drill. There should be at least 12 mm bony bridge between the two guide pins.

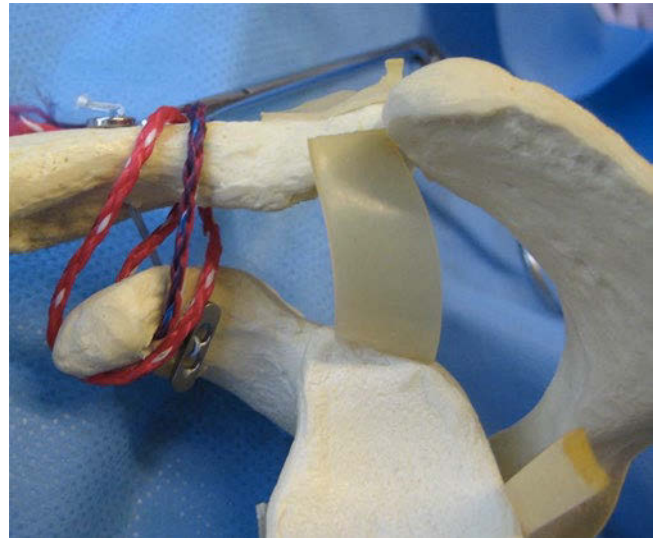
The second guide pin is then over drilled with the 4 mm cannulated drill, which is removed after passing a doubled



■ Fig. 2.18a,b Arthroscopic view. a Insertion of the two guide pins with the AC guide. b Pulling the gracilis tendon graft through the coracoid



■ Fig. 2.19 Pulling the gracilis tendon



■ Fig. 2.20 Passing the gracilis tendon graft in a modified figure of eight manner in a saw bone model

shuttle suture. The gracilis tendon, threaded the loop of the shuttle suture, is pulled from the clavicular side downwards (■ Figs. 2.18b and 2.19) and the distal end of the graft is driven outside through the anterosuperior working portal.

The distal short tail of the graft, emerging from undersurface of the coracoid, is then pulled proximally with the help of a shuttle suture introduced anterior to the clavicle and lateral to the coracoid. The other long tail of the graft exiting the clavicular tunnel is pulled with the help of shuttle suture anterior the clavicle and passed medial to the coracoid into the joint. This tail is further pulled proximally with a grasper introduced posterior to the clavicle and lateral to the coracoid so that it passes under the coracoid and ultimately making a modified figure of eight around the clavicle and the coracoid (■ Fig. 2.20).

The anatomical reduction of the AC joint is checked with an image intensifier followed by tightening and securing the

sutures over the clavicular button with at least 5 knots with reversing the posts. Both ends of the graft are then sutured together above the clavicle in side to side technique with non-absorbable sutures.

2.4.5 Postoperative Management

- Positioning of the arm in an arm sling
- Monitoring of peripheral circulation, motor and sensory innervations.
- Postoperative X-ray evaluation.

2.4.6 Follow-Up Management

Immobilization in an arm sling for 6 weeks, with limitation of the range of motion during physiotherapy and rehabilitation as follows:

- 1.–2. weeks passive : 30° abduction, 30° flexion, 80° internal rotation, 0° external rotation
- 3.–4. weeks active-assisted: 45° abduction, 45° flexion, 80° internal rotation, 0° external rotation
- 5.–6. weeks active: 60° abduction, 60° flexion, free internal and external rotation
- After the 7th postoperative week, free movements and after 3 months full load bearing are allowed.

2.4.7 Tips & Tricks

The patient head should be tilted about 20° to the opposite side during positioning to have a sufficient space for placement and drilling of the bone tunnels.

A careful release of the coracoid undersurface with complete exposure of the entire base as well as the medial and lateral edges is crucial to ensure optimal positioning of the drill tunnels through the coracoid.

Anatomical reduction of the ACJ should be carried out with the help of a pneumatic arm holder under radiological control before introducing the drill guide and drilling the bone tunnels. The reduction should be checked again and corrected if necessary before tightening and securing the Sutures. (■ Fig. 2.10). Open reduction must be performed if closed reduction is not possible (e. g. due to soft tissue interposition).

For precise placement of the clavicular drill tunnels in the center of the clavicle, the anterior and posterior margins of the clavicle should be clearly visualized through insertion of 2 small Hohmann retractors.

The placement of the guide wires as well as drilling the tunnels can be optionally performed under radiological control with an image intensifier.

Some authors recommend an additional acromioclavicular stabilization (e. g. with acromioclavicular cerclage) if there is marked horizontal ACJ instability.

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