Technical Note

Free Hand Drilling Technique to Enhance Central Position of Tunnels in Arthroscopic Acromioclavicular Joint Fixation Using TightRope System

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Abstract: Acromioclavicular joint (ACJ) dislocations represent one of the most common lesions in the shoulder. Arthroscopic reduction and ACJ fixation with the button system is one of the most used techniques for displaced and unstable dislocations. Difficulties with placing the tunnels in the central and correct position of the clavicular and coracoid can occur with the use of a guide, which can result in fractures, eccentric tunnel position, cortical rupture, prolongation of surgical times with its complications as bleeding, tissue infiltration, difficult visualization, and increased risk of infection. Prior free hand central tunnel placement in the clavicle with a 3.2 mm drill helps to keep in place the pin guide over the superior cortical of coracoid with reduction of guide movement to enhance the correct position of tunnel in the coracoid process avoiding bone complications.

Acromioclavicular joint (ACJ) injuries represent up to 50% of athletic shoulder injuries. Treatment of this instability is based on the Rockwood classification, which depends on the clavicular displacement characteristics.[1-4] More than 100 surgical techniques have been described for the treatment of ACJ injuries.[5] However, many surgeons use arthroscopic coracoclavicular (CC) suture button fixation.[2,6-10] This procedure is not exempt from complications related to technical difficulties as clavicular or coracoid process fracture, loss of fixation, or graft failure.[11-13] In suture button techniques, the incidence of clavicle and coracoid fractures is reported to range from 27.1% to 44%, with most of those caused by drilling an eccentric hole.[1,14,15] Clavicular fracture risk is directly related to the number of tunnels performed because of inaccurate precision of drilling guide systems.[16] Spiegel found that a smaller drill creates a lower risk of clavicle fracture.[2,17,18]

The free-hand clavicle pre-drilling to mark correct placement of the tunnel with a small pin guide can reduce the risk of clavicle fracture caused by multiple attempts to place a correct bone tunnel with an inaccurate guide. It is important to consider that the ideal position of the tunnel in the clavicle is 25 to 45 mm medial to the ACJ, where the bone density is higher and the risk of fracture is lower.[18,19]

Difficulties in the central and correct position of tunnels is not infrequent with the use of button system guides, which can result in eccentric tunnel position, cortical rupture, and prolongation of surgical times with its complications. Fractures of the coracoid or the clavicle remain a significant complication occurring predominantly with techniques using these bony tunnels. Multiple passes of the drill through the clavicle during implant positioning is a predominant risk factor. It is important to create tunnels in the correct position to avoid widening a tunnel. To minimize the risk of clavicle and coracoid fracture, prior accurate free hand tunnel placement in the distal third of the clavicle permits leading the pin guide tip into a centered position of the axillary coracoid.

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The aim of this technique is to ensure correct positioning of the bone tunnel in the clavicle and coracoid process during ACJ fixation with the button system with a prior free hand clavicular drilling to reduce surgical time and complications when the guide is not accurate. Arthroscopy makes it possible to get a straight vision of the superior and inferior aspect of the base of the coracoid, a particularly important anatomical area to place the bone tunnel in correct position when CC fixation systems are used.

Surgical Technique

Anesthetic Technique

A brachial plexus block is performed with an interscalene approach under ultrasound guidance. After sedation the patient is placed in a supine position with the arm adducted, the hand resting on the abdomen, and the head slightly lateralized to the opposite side of the site to be blocked. The transducer or high-resolution linear probe is placed transversely to the neck 2 to 2.7 cm from the clavicle over the external jugular vein that will serve as a reference. The needle is inserted flat and from lateral to medial in the space between the median and anterior scalene muscles, placing the tip of the needle between C5 and C6, guided by the traffic light sign (stoplight sign), and the fascia is crossed, leaving the anesthetic local between C5 and C6.

Diagnostic Arthroscopy and Coracoid Exposure

The patient is placed in the beach chair position with a mechanical arm holder (Fig 1). Anatomic landmarks are identified and drawn on the skin, and 3 arthroscopic portals (posterior, anterior and anterolateral) are placed. The procedure starts with diagnostic arthroscopy looking for associated injuries. Preparation of the coracoid base is performed through anterior portal. The rotator interval is opened using a radiofrequency device (Fig 2). The coracoid base is clearly visualized from the anterolateral portal.

Prior Free Hand Clavicular Drilling

A surgical ruler is used on the superior aspect of the clavicle to mark the position of 2.5 cm from the lateral-most aspect of the clavicle with either a coagulator or surgical pen. A 2 cm incision is completed on the basis of Langer's lines. A bicortical pilot hole of 2.4 mm pin guide is created in the center of the superior cortex and about 25 mm medial to the lateral end of the clavicle (Fig 3). Under direct visualization using anterior and posterior mini Hoffman retractors, we confirm the correct position of the tunnel considering anteroposterior clavicular cortex and medial-distal clavicular border. Then a 3.2 mm tunnel is performed using a cannulated drill bit (Fig 4). This wider hole will be used as a safe reference point to lead and keep in place the pin guide over the center of the coracoid process to make perforations by free hand drilling (Fig 5).

Fig 1. Patient position. Right shoulder, the stability of the shoulder and acromioclavicular joint reduction in is performed with the patient in the beach chair position with a mechanical arm holder. Is evident the prominence of distal clavicle before reduction. It is important to prepare and drape in the normal sterile condition leaving sufficient exposition of the anterior and posterior shoulder to have enough sterile area to draw portal and incisions. The C-arm should be prepared on the contralateral side to analyze anatomical reduction.

Placement of Coracoid Tunnel With CC Guide

The CC guide is introduced through the anterolateral portal, and the exit point of the guide is held under the center of the coracoid's base (Fig 6A). This placement is confirmed by direct scope visualization through posterior standard portal. At this point, the guide pin sleeve is positioned and fixed into the predrilled 3.2 mm clavicular hole. Using a power drill, the 2.4-mm drill guide pin is advanced through the coracoid (Fig 6B), once the pin is correctly positioned, the 3.2 mm hole is created, and the nitinol guide is inserted into the joint to pull in the implant (Fig 6C). The tip of the guide pin should be captured by the drill stop at the base of the coracoid under direct visualization (Video 1). However, if the tip of the guide pin is placed inaccurately by the guide, we switch to a free-hand technique to avoid additional attempts that produce bone weakening and risk of coracoid fracture.

Free Hand Coracoid Redirection Tunnel Drilling

If the coracoid tunnel has been difficult to place in a correct position with the use of the CC Guide, we prefer

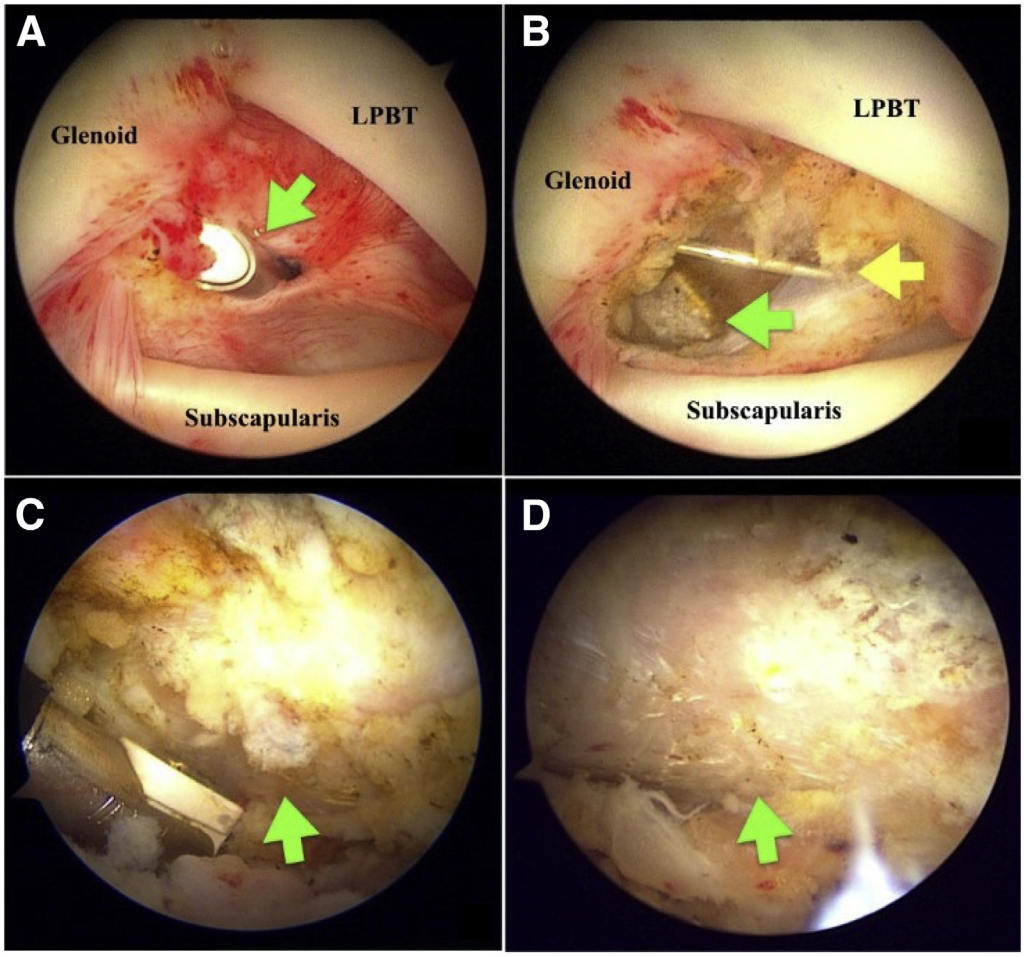

Fig 2. Arthroscopic views of the right shoulder. Diagnostic glenohumeral arthroscopy is performed using a 40-mm 30° arthroscope through the posterior portal. Preparation of the coracoid base is performed via a trans interval approach. The rotator interval is opened using an electrothermal device and a soft tissue shaver (A). Once the interval is open, the lateral portal is stablished using a spinal needle (18G) directed to the coracoid (B). The arthroscope is placed in the posterior portal and then is changed to the lateral direct portal to assess a better visualization of inferior aspect of the coracoid and to remove any remain soft tissue (C). The coracoid base is clearly visualized in a medial to lateral margin to assess the base center (D).

to remove it and redirect the guide pin through the 3.2 mm clavicle bone tunnel by free hand using a direct visualization of the superior cortical of the coracoid process through the anterolateral portal (Fig 7). The superior cortex of the coracoid is cleaned and exposed using shaver and radiofrequency, the pin guide is led and placed in the center of the coracoid process (Fig 8 A-C). The pin is advanced carefully through the coracoid, and a spoon can be introduced through the anterior portal and placed under the tip of the drill guide (Fig 8D). Finally, the 3.2 mm cannulated drill is advanced over the pin through the coracoid (Fig 8E), and the nitinol guide is introduced into the joint to release the implant (AC Tightrope, Arthrex, Naples, FL) (Fig 8F) (Video 1). After the clavicle and coracoid tunnels are correctly placed (Fig 9), the AC joint reduction and fixation are performed in the standard manner (Fig 10) (Table 1).

Final Steps and Considerations

After coracoclavicular fixation, assessment of clinical appearance is performed (Fig 11), and anteroposterior radiography of the shoulder is performed to evaluate the correct position of the implants and the adequate reduction (Fig 12).

Risk and Limitations of the Free-Hand Drilling Technique

The free-hand drilling technique has potential risk and limitations related to acromial erosion, wound infection, joint malreduction, and clavicular and coracoid fractures. It is important to have direct visualization when placing the pin guide over the coracoid to avoid drilling the hole too medially or laterally, which could produce a fracture. Therefore it is important that the arthroscope and the working portal must be handled anterolaterally and anterosuperiorly. By not changing portals or using a 70° arthroscope, one is at high risk of placing tunnels too far anteriorly, where the diameter of the coracoid is only 5 to 7 mm, and not at the base of the coracoid, where they should be placed.

Risk of clavicle fracture with this technique is also present because of technical errors resulting from multiple passes of the drill through the clavicle when the initial position of the pin guide is not placed in the appropriate area (25 to 45 mm medial to the ACJ)

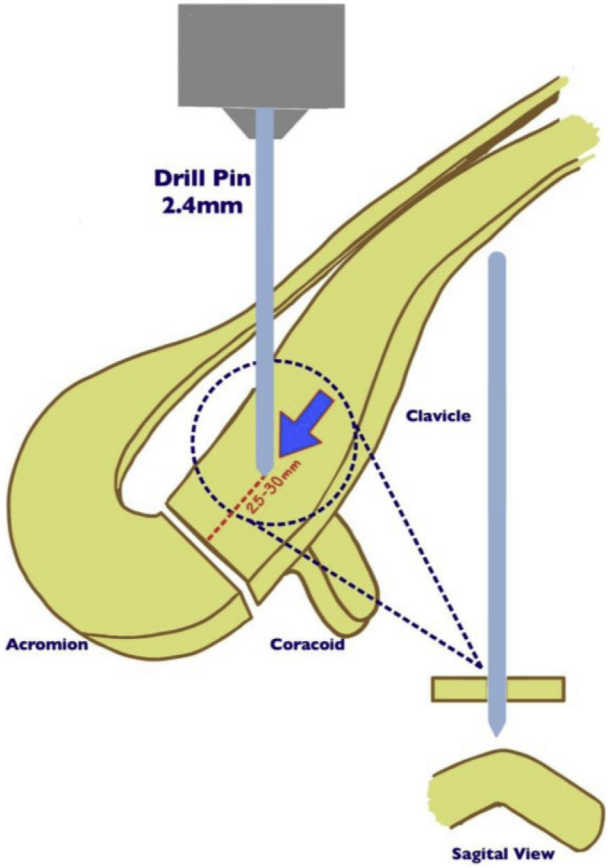

Fig 3. Scheme of a right shoulder showing the ideal placement of pilot hole in the clavicle. For the clavicular approach, a surgical ruler is used on the superior aspect of the clavicle to mark the position of 25 to 30 mm (arrow) from the most lateral aspect of the clavicle with either a coagulator or surgical pen. A 20 mm incision is completed based on Langer's lines. Clavicular drilling pilot hole is performed by using a 2.4 mm pin guide, placed in the center from anterior to posterior borders of the superior cortex and about 25 mm medial to the lateral end of the clavicle. It is important to get a wide visualization of anterior and posterior edges of the clavicle using 2 mini Hoffman retractors. In this step is not necessary to keep arthroscope visualization.

where the bone density is higher and the risk of fracture is lower. The appropriate distance from the pilot hole to the lateral edge of the clavicle may help decrease the risk of clavicle fracture. To enhance precise hole placement the first time and to reduce technical errors in the clavicle, drilling is important to get a good view that avoids bleeding and small incisions, performing a wide clavicle dissection, and using anterior and posterior Hoffman retractors. A clavicular hole made too anteriorly can cause clavicular button migration inferiorly to the subcoracoid region.

Discussion

The main goal of clavicular before drilling is to create a more reliable technique in CC bone tunnel fixation arthroscopy-assisted system, decreasing surgical time and perioperative complications when the CC Guide is not accurate to perform correct clavicular and coracoid tunnel placement. Complications after with surgical treatment of ACJ range from 27% to 44%. The 5 most commonly documented complications of arthroscopic fixation are superficial infection (4%), shoulder pain (27%), CC calcification (32%), fracture (5%), and loss of reduction (27%). Clavert et al.[17] prospectively reported a complication rate of 27% in 116 primary anatomic button fixations. The most serious complications are graft failure, hardware complications, and distal clavicle or coracoid fractures as a result of the bone tunnels. Coracoid/clavicle fractures remain a significant complication that occur predominately in techniques using bone tunnels.[20-22]

Prior clavicular drilling permits keeping the pin sleeve guide in a more secure and desired position from the beginning of the technique. This predrilled hole permits creating under direct view a right-center unicortical hole in the predefined place to ligament reconstruction or coracoclavicular fixation. Clavicular and coracoid bone tunnels lead a risk fracture in both locations, and reported rates of clavicular fractures have ranged up to 18% in

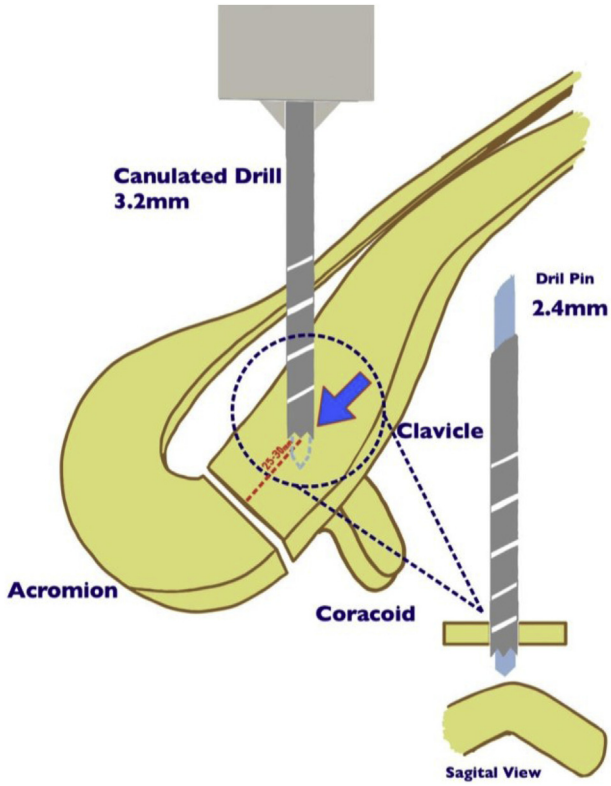

Fig 4. Scheme of a right shoulder showing the drilling of 3.2 mm hole in the clavicle. Once the 2.4 mm pilot hole is set in the desired position in the clavicle, the pin guide is left into the pilot hole to prevent displacement, then a 3.2 mm tunnel is drilled using a cannulated drill bit to make a bicortical perforation in the clavicle.

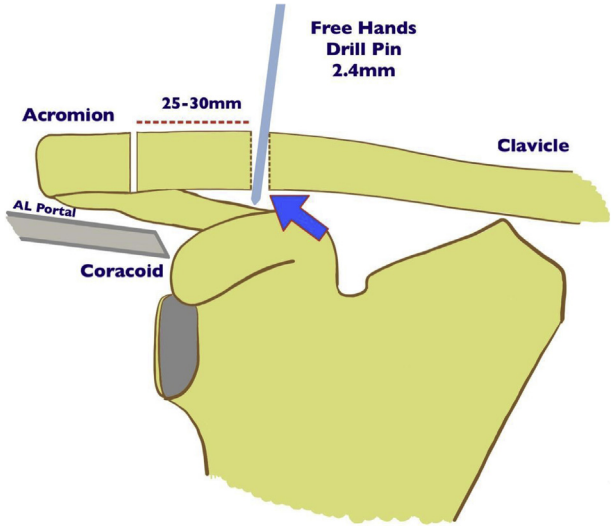

Fig 5. Scheme of a right shoulder in coronal view where is easy to observe the position of the 3.2 mm pilot hole in the clavicle. The arthroscope placed in the lateral portal permits a direct view of the superior aspect of the coracoid. This wider hole is used as a safe referenced point to lead and to keep in place the pin guide over the center of the coracoid process to make perforations by free hand drilling technique. Using this wider hole facilitates the free movement of the guide pin from medial to lateral and from anterior to posterior over the coracoid process. AL, anterolateral.

patients with tunnels drilled in the clavicle, most of which are caused by a eccentrical hole drilled in the distal third of the clavicle.[2-7] Biomechanical evidence shows that any repair that involves drilling increases the risk of clavicle fracture.[2-5] These studies show that smaller drills have a lower risk of clavicle fracture.[2,7] Those reports support the principle predrilling in a correct place of the clavicle surface before bottom guide drilling. Then to the 2.4 mm hole only in the clavicle we recommend drilling the 3.2 mm tunnel, which strongly keeps in place the drill sleeve guide preventing undesirable movements over the clavicular cortex. The second benefit of this technique is that, by having a wider hole in the clavicle before drilling the coracoid tunnel, it permits placing by free hand the drill pin over the superior coracoid cortex and redirect it to the desire position using an intra-articular curve Kocher clamp—when the direction of the CC Guide is not accurate.

The described procedures provide simple modifications of the ACJ conventional button fixation technique. The aim of these additional steps is to make a more reproducible and reliable technique to perform more accurate bone tunnels either in the clavicle and coracoid when the CC Guide does not permit placing the drill pin guide in a centered and correct position. This technique can reduce dead surgical times because of a repeatable failure drilling with consequent weakening of bone and clavicular and coracoid fractures (Tables 2 and 3).

Conclusion

Prior free hand central tunnel placement in the clavicle helps lead correct positioning of the pin guide over the superior cortical of coracoid to enhance 1-step tunnel accuracy, reducing surgical times and complications caused by repeatable fail drilling with consequent weakening of bone and clavicular and coracoid fractures.

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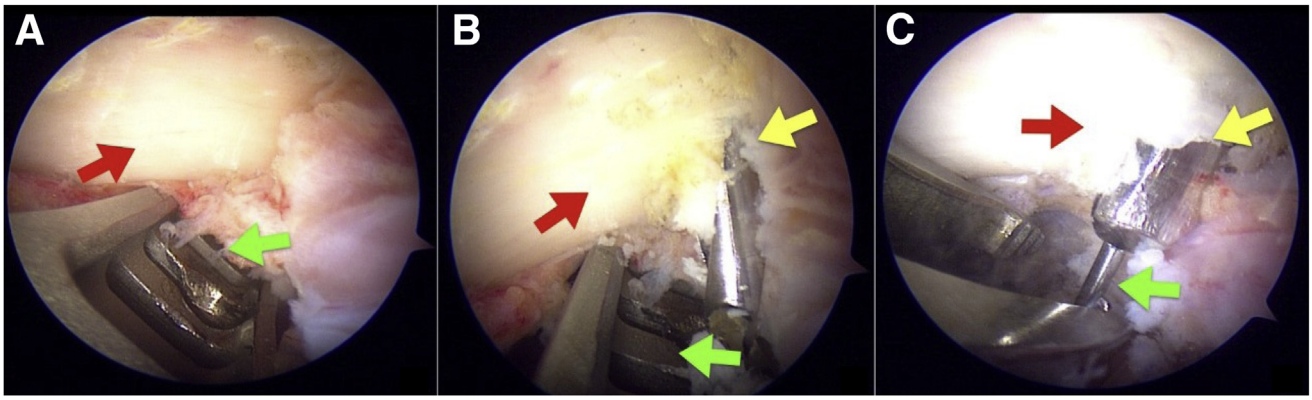

Fig 6. Arthroscopic view of a right shoulder shows the coracoid drilling in standard manner using a coracoclavicular guide (A) (green arrow). This is introduced through the anterolateral portal while the arthroscope is placed in the posterior portal. The exit point of the guide is held under the center of the coracoid's base (A) (red arrow). At this point, the guide pin sleeve is positioned and fixed into the predrilled 3.2 mm clavicular hole. Using a power drill, the 2.4-mm drill guide pin is advanced through the coracoid (B) (yellow arrow). Once the pin guide is in correct position in the base of the coracoid, then the 3.2 mm hole is created, and the nitinol guide is inserted into the joint to pull in the implant (C) (green arrow) (Video 1).

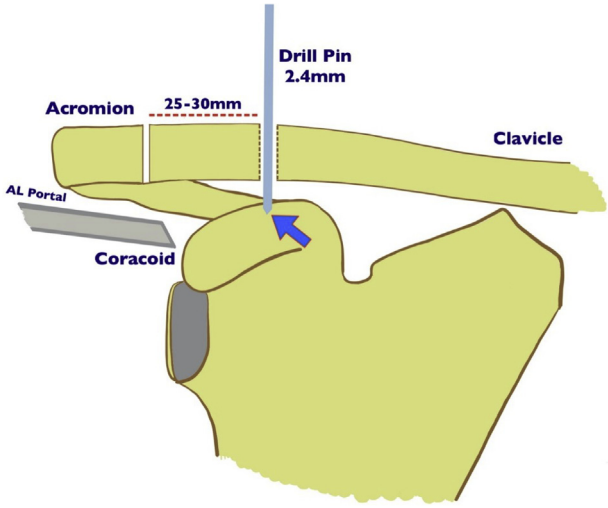

Fig 7. Scheme of a right shoulder in coronal view. If the coracoid tunnel has been difficult to place in a correct position with the use of the coracoclavicular guide, we prefer to remove it and redirect the guide pin through the 3.2 mm clavicle bone tunnel by free hand using a direct visualization of the superior cortical of the coracoid process through anterolateral (AL) portal (arrow), this permits free movement of the pin guide in the middle of anterior and posterior border of coracoid.

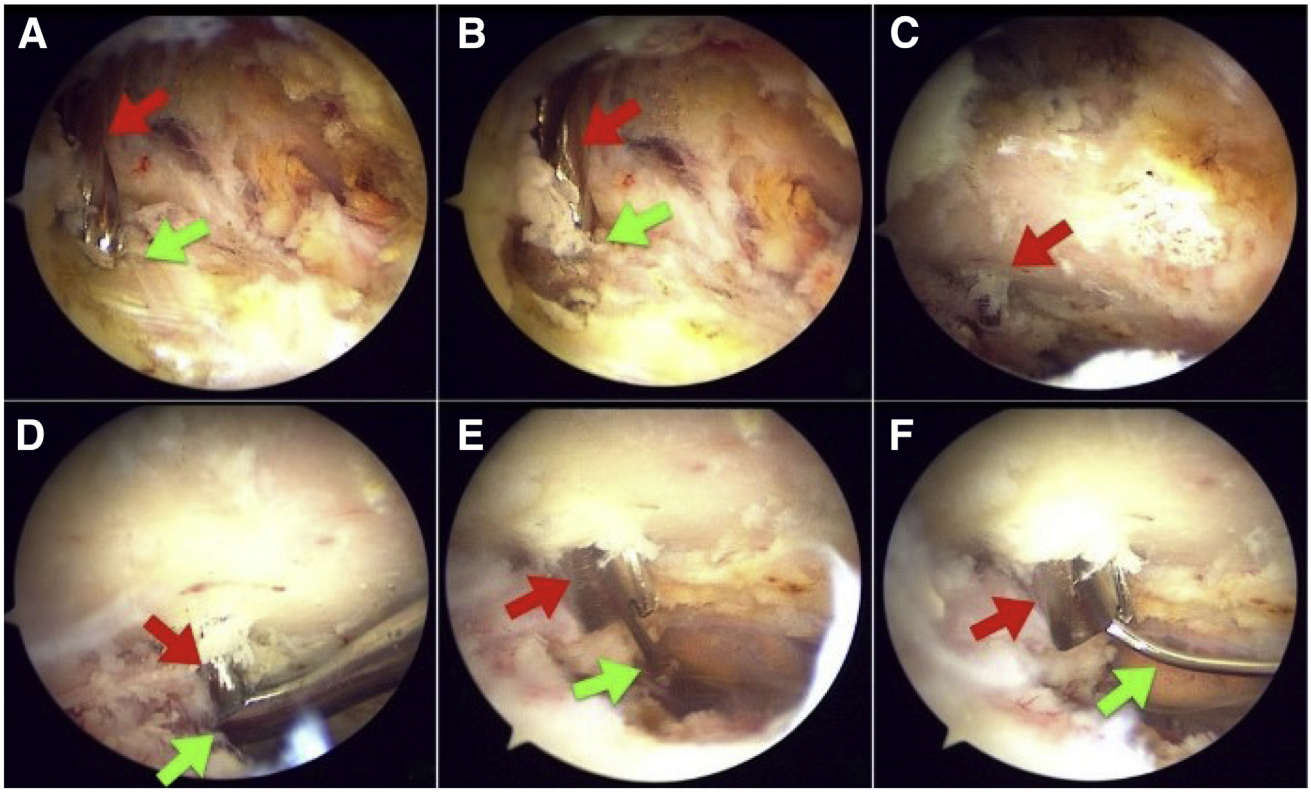

Fig 8. Arthroscopic view of a right shoulder shows coracoid drilling by free hand technique. The superior cortex of the coracoid exposed, and the 2.4 mm pin guide (red arrow) is placed over the center of the anterolateral and posteromedial borders of the coracoid process (green arrow) by direct view with the arthroscope in the lateral portal (A and B). When the pin guide is placed in the desired position, this is advanced carefully through the coracoid until its inferior cortical (C), a spoon is introduced through anterior portal (D) (red arrow) to catch the cannulated 3.2 mm drill (D) (green arrow). The cannulated drill is advanced over the pin through both cortical of coracoid (E) (red arrow), the nitinol guide (F) (green arrow) is pulled into the joint through anterior portal to introduce the button fixation (Video 1).

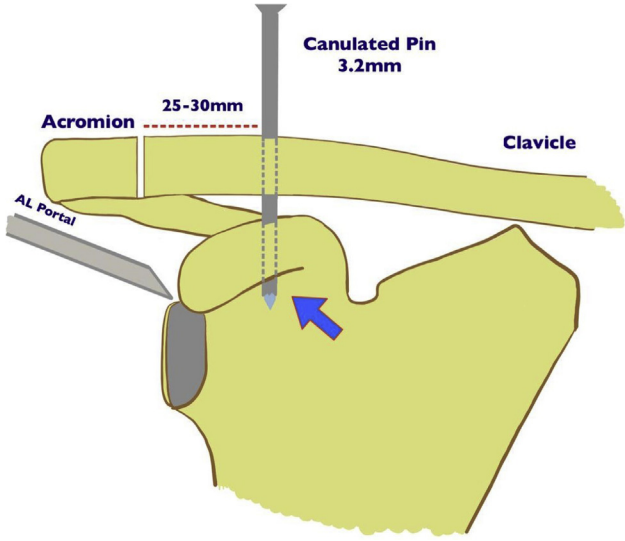

Fig 9. Scheme of a right shoulder in coronal view. Once the 2.4 mm pin guide is place in the adequate area either in the clavicle and coracoid, is safe to introduce the cannulated 3.2 mm drill and start the perforation of coracoid process. Is important to keep in place the pin guide to avoid false or incorrect tunnels and to maintain the direct visualization through anterolateral (AL) portal during this step.

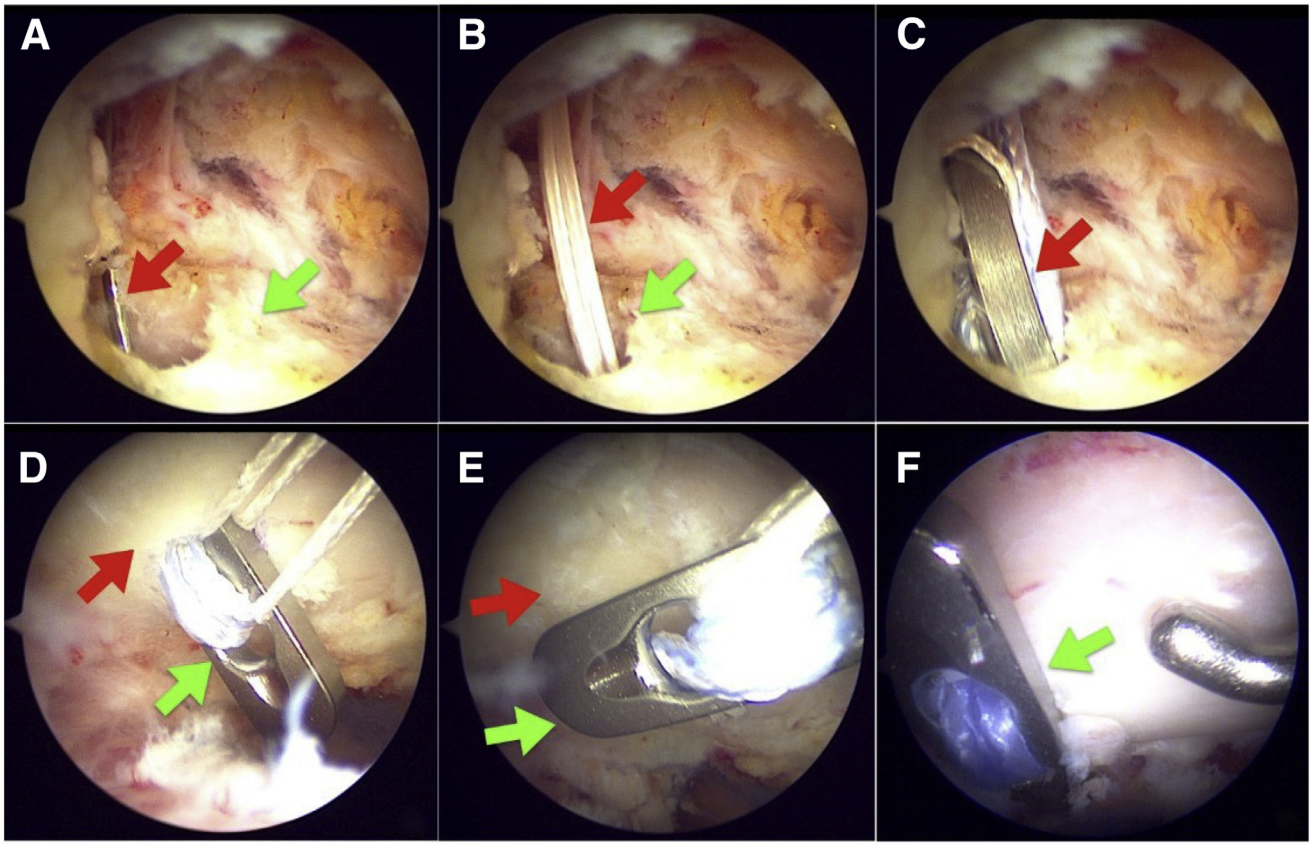

Fig 10. Arthroscopic view of a right shoulder shows the introduction of button system. Once the overdrilling has been done, the 2.4 mm pin guide is taken away (A) and instead the nitinol guide is introduced into the cannulated drill to catch it into the subcoracoid space. The cannulated drill is retired carefully from the tunnels and the nitinol guide is pulled through anterior portal to permit the introduction of the sutures (B) (red arrow) attached to the button system. The button is passed vertically (C) (arrow) into the clavicular and coracoid tunnels and then flipped (D and E) and fixed under the base of the coracoid process (F) by pulling one of the traction sutures. In this step, acromioclavicular (AC) joint reduction is performed in the anatomical position under pressure using the fluoroscopic visualization.

Table 1. Essential Stages for Free Hand Drilling Technique

Step	Zone	View	Description
1	Anterior interval	Posterior portal	Coracoid process cleaning
2	25 mm from ACJ	Direct	Clavicle free hand drilling (2.4 mm)
3	25 mm from ACJ	Direct	Clavicle free hand drilling (4 mm)
4	Coracoid	Anterolateral portal	Lead the pin in the center of axillary coracoid process
5	Coracoid	Anterolateral portal	Coracoid drilling (2.4 mm)
6	Coracoid	Anterolateral portal	Coracoid drilling (4 mm)
7	Bone tunnels	Anterolateral portal	Button placement and ACJ reduction

ACJ, acromioclavicular joint.

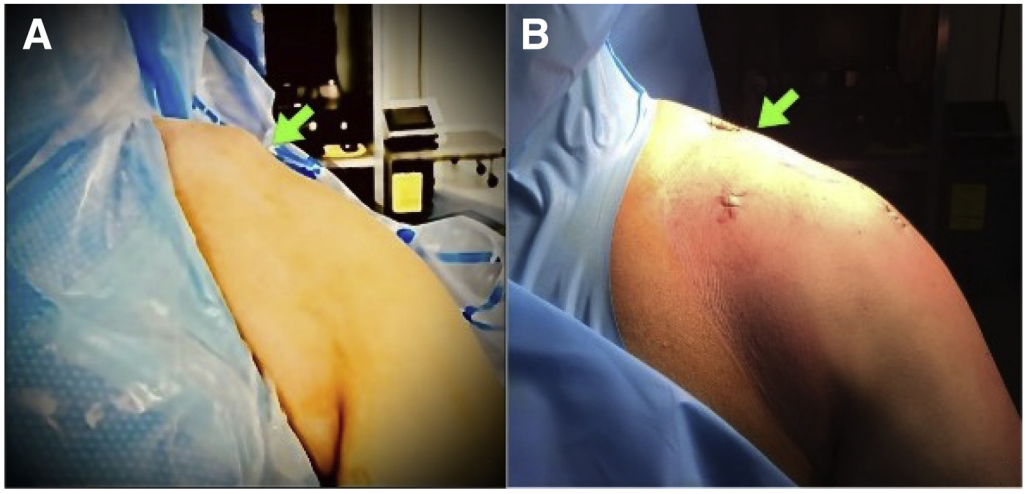

Fig 11. Left shoulder clinical evaluation in the operating room. After coracoclavicular fixation, assessment of clinical appearance is performed. Preoperative deformity is clearly evident with the displacement of acromioclavicular (AC) joint (A) compared to the absence of protrusion and clinical alignment after AC joint reduction and fixation with button system (B).

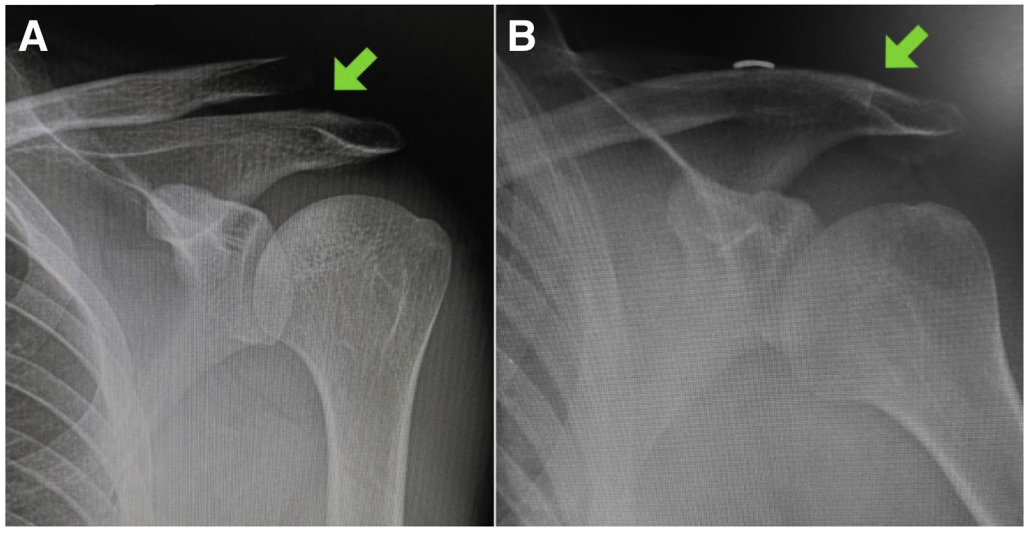

Fig 12. Anteroposterior view of the left shoulder. Preoperative radiogram shows a Rockwood grade III acromioclavicular (AC) joint the dislocation (A) (arrow). Postoperative control radiogram where complete reduction of AC joint (B) (arrow) is observed with the button fixation system. The clavicular and coracoid buttons are in a centered and acceptable position in the anteroposterior plane.

Table 2. Advantages and potential limitations

Advantages
No need for special CC guide
No need of arthroscopy proficiency
Satisfactory placement of bone tunnels
Reduce bone weakening risk
Reduce risk of fractures
Reduce dead surgical times
No skin incision over the tip of the coracoid
Proper view of the superior coracoid cortex
No need of 70° arthroscope
Anatomic CC reduction
Limitations
Moderate technical demand
Steep learning curve
Disturbing the musculocutaneous nerve

CC, coracoclavicular.

Table 3. Pearls and Pitfalls

Pearls
Langer's lines for cosmetically better appearance
Drill the pilot hole 25 mm from ACJ
Complete exposure of superior cortical of coracoid
Use anterolateral portal for direct view
Lead the pin guide in the axillar center of coracoid
Make sure the correct position of 2.4 mm before drilling a wider hole (4 mm)
Use intraoperative fluoroscope to confirm reduction
Pitfalls
Neurovascular damage
Correct direction of drill pin in the clavicle and coracoid
Failure to clear soft tissue around coracoid
Protect the conjoint tendon
Disturbing the musculocutaneous nerve
Poor exposure of distal clavicle area

ACJ, acromioclavicular joint.

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