Technical Note

Arthroscopic Distal Clavicular Autograft for Congruent Glenoid Reconstruction

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Abstract: Arthroscopic distal clavicular autograft (DCA) is effective in shoulder instability with glenoid bone loss. The original technique uses an osteochondral autograft, fixed with screws or suture anchors. We developed a modified procedure called "congruent arc DCA" characterized by (1) use of drilling guides to optimize graft positioning and make the all-arthroscopic procedure safer and reproducible; (2) rotation of the DCA of 90° to reach a congruent arc with its undersurface; (3) fixation of the graft with cortical buttons to simplify its intra-articular passage, avoid hardware problems, and facilitate possible revision surgery; and (4) intraoperative use of a suture tensioner to achieve satisfactory compression of the graft and increase its consolidation.

In anterior shoulder instability, glenoid bone loss can be addressed using various bone grafting techniques. There are autografts such as the coracoid[1-4] and the iliac crest[5-9] or allografts.[9-11] Both types have some limitations and morbidities.[12-15]

In 2014, Tokish et al.[16] published a Technical Note describing the reconstruction of a deficient glenoid using a distal clavicular autograft (DCA). This source of graft is appealing in terms of prompt availability, safeness, and elimination of donor-site morbidity.

The distal clavicle was used as a fresh osteochondral autograft, fixed either with screws or suture anchors. Its cartilaginous articular surface was meant to repristinate the glenoid.

Promising anatomic and biomechanical results have been reported with the use of osteochondral DCA.[16-19] However, cartilage degeneration is not rare, mostly in athletes, and, in our experience, the shape of the distal clavicle cartilage is rarely concave. Furthermore, drilling anteriorly, under arthroscopy, is potentially dangerous for neurovascular structures and screw fixation of the bone graft is a known source of complications and revision.[20-25]

We developed a modified arthroscopic DCA procedure for congruent glenoid reconstruction characterized by (1) use of drilling guides to optimize graft positioning and make the all-arthroscopic procedure safer and reproducible[26-28]; (2) rotation of the DCA of 90° to reach a congruent arc with its undersurface; (3) fixation of the graft with cortical buttons, to simplify its intra-articular passage, avoid hardware problems, and facilitate any revision surgery[26-28]; and (4) intraoperative use of a suture tensioner to achieve satisfactory compression of the graft and increase its consolidation.

Surgical Technique (With Video Illustration)

Our surgical technique is presented in Video 1. The goal of the procedure is to restore the glenoid surface using DCA. We transfer the graft inside the glenohumeral joint, passing through the rotator interval and fixing it with cortical buttons. We use the under table of the clavicle, which is concave, to recreate the articular surface, creating a "congruent construct" (Fig 1).

Arthroscopic-Guided System and Cortical Buttons

Instrumentation used for DCA is the same of arthroscopic Latarjet or Eden–Hybbinette procedures.[27-29] The senior author developed instrumentation that is commercially available (Latarjet Guiding System;

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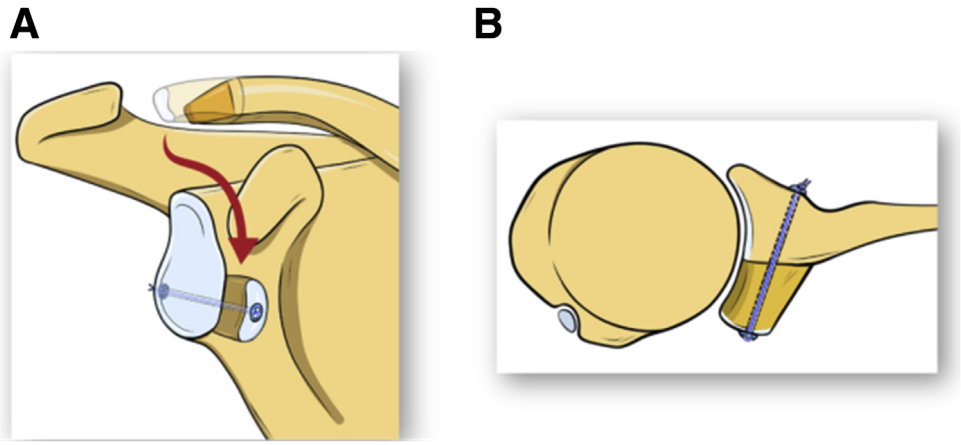

Fig 1. Arthroscopic glenoid reconstruction with a congruent arc distal clavicle autograft (DCA). (A) After arthroscopic subperiosteal dissection, osteotomy and drilling, the DCA is transferred through the rotator interval onto the glenoid neck. (B) The portion of DCA is rotated of 90° to provide a "congruent arc construct" with its undersurface and fixed with 2 cortical buttons, after tensioning the sutures.

Smith & Nephew, Andover, MA). The fixation devices (Bone-Link; Smith & Nephew) consist of 2 purpose-designed titanium cortical buttons with no. 3–4 ultrahigh-molecular-weight polyethylene suture sling, running through them. Although 4 buttons can be used, based on the senior surgeon's experience, a 2-button construct is enough to obtain a solid graft fixation and healing.[26-29] Pearls and pitfalls of this surgical procedure are shown in Table 1.

Positioning and Portal Establishment

The patient is in "lazy" beach chair position, with a 30° of head elevation, to facilitate the cerebral perfusion. The arm is placed on a mobile holder (SPIDER Limb Positioner; Smith & Nephew), without any static traction. Portals are posterior, lateral, anteromedial, and anterolateral. The arthroscope is 70°, and it is introduced in a standard posterior portal. A complete diagnostic arthroscopy is performed.

Step 1: Opening of the Rotator Interval

Using the arthroscope in the lateral portal and either a motorized shaver and/or a radiofrequency ablation device (Smith & Nephew) in the anterolateral portal, the rotator interval is fully opened (Fig 2). This step is crucial to facilitate the lateral transfer of DCA into the glenohumeral joint. Insufficient opening can make further steps difficult or impossible.

Table 1. Pearls and Pitfalls

Pearls	Pitfalls
• Opening the rotator interval is a crucial step. Insufficient opening can make further steps difficult or impossible	• During glenoid preparation, not sufficient use of motorized power rasp can result in poor graft match
• Positioning suture anchors for further Bankart repair during glenoid preparation step, because they will represent landmarks for successive graft positioning	• If the cut of the distal clavicle is not slightly oblique, from medial to lateral, the match with glenoid surface can be difficult
• For best positioning of the graft, use a probe to place it flush with the articular glenoid surface	• If the K-wire is too vertical, graft mismatch or fracture is possible.

Step 2: Glenoid Preparation and Drilling

After complete elevation of the anterior labrum, glenoid neck is prepared to obtain a flat cancellous surface, using a motorized power rasp. Two suture anchors (FAST-FIX; Smith & Nephew) are positioned at 3′ and 5 o′ clock of the glenoid rim. They are landmarks for graft positioning, and at the end of the procedure, they will

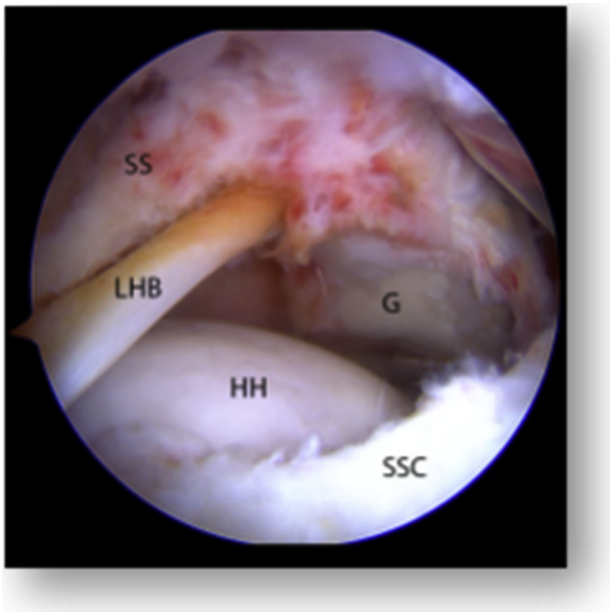

Fig 2. Visualization of the glenohumeral joint through open rotator interval, viewed from the lateral portal. Intraoperative image of the right shoulder. The arthroscope is positioned in the lateral portal, in order to have a fully glenohumeral joint view through the rotator interval. (G, glenoid surface; HH, humeral head, LHB, long head of the biceps, SS, supraspinatus tendon, SSC, subscapularis tendon.)

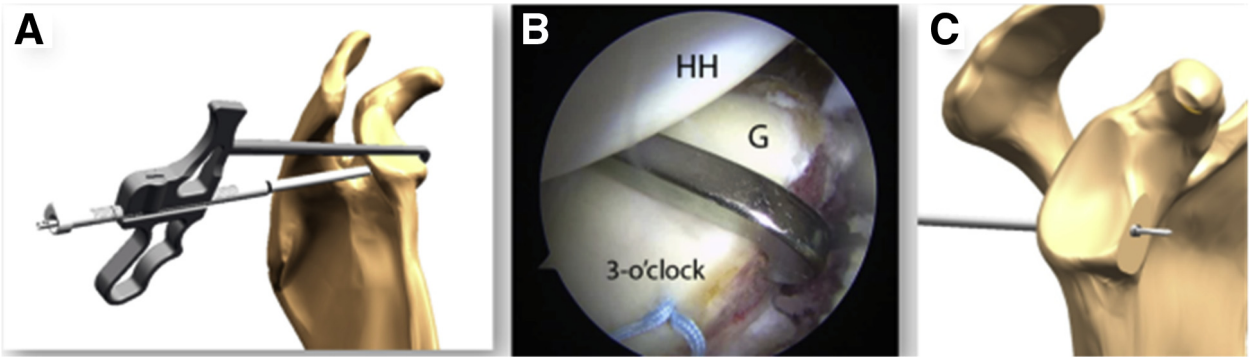

Fig 3. Glenoid preparation and drilling. (A) After glenoid neck abrasion, a specific hooked glenoid guide (Smith & Nephew) is introduced through the posterior portal, between the glenoid (G) and the humeral head (HH). (B) Arthroscopic view of the right shoulder showing the glenoid neck. The arthroscope is moved to the anterolateral portal. The guide, introduced through the posterior portal, must be flush to the glenoid surface and located at 4-o'clock position. A cannulated K-wire (2.8 mm) is drilled through the guide, across the glenoid. (C) The glenoid drilling is guided and remains intra-articular, eliminating neurological complications or further work close to the brachial plexus.

be necessary for the labral repair. A PDS (polydioxanone) suture (ETHICON, a subsidiary of Johnson & Johnson, Somerville, NJ) is passed through the labrum at 5 o'clock to retract it laterally and making easier the introduction of the bone graft.

The arthroscope is moved to the anterolateral portal and the glenoid guide is introduced over a half-pipe, through the posterior portal. The guide must be flush to the glenoid surface and hook the glenoid rim at 4 o'clock (Fig 3).

A specific 2.8-mm cannulated drill bit with an outer sleeve is drilled through the guide, across the glenoid. Once visualized, the sleeve emerging through the front of the glenoid neck, the guide is removed, and the drilled k-wire is left in situ.

Step 3: Distal Clavicle Dissection, Drilling and Osteotomy

Using a radiofrequency device, a subcapsular and subperiosteal dissection is performed to expose the distal clavicle (Fig 4). The acromioclavicular joint (AC) is visualized from underneath, and the intra-articular synovial tissue is removed. With a graduated probe and a spinal needle, an evaluation of the amount of clavicle resection is made; usually 10-mm bone graft is sufficient to reconstruct up to 30% of bone loss.[16] With a 0.5-mm high-speed oscillating saw, an osteotomy of the distal clavicle is performed. The cut is slightly oblique, from medial to lateral, to mirror the obliquity of the anterior glenoid neck.

Drilling of distal clavicle is performed with the help of a specific 3-arms guide (Coracoid Drill Guide). From a technical standpoint, 2 drilling options are possible: drilling before the osteotomy, after lowering the clavicle under the acromion, with the guide through the lateral portal; alternatively, drilling after the osteotomy, clamping the cancellous side of the distal clavicle with the guide, and creating a tunnel through the bone block (Fig 5). A second 2.8-mm cannulated drill bit is drilled through the guide in the graft. A PDS suture is passed through the cannulated sleeve and the bone block. After that, the outer sleeve is removed.

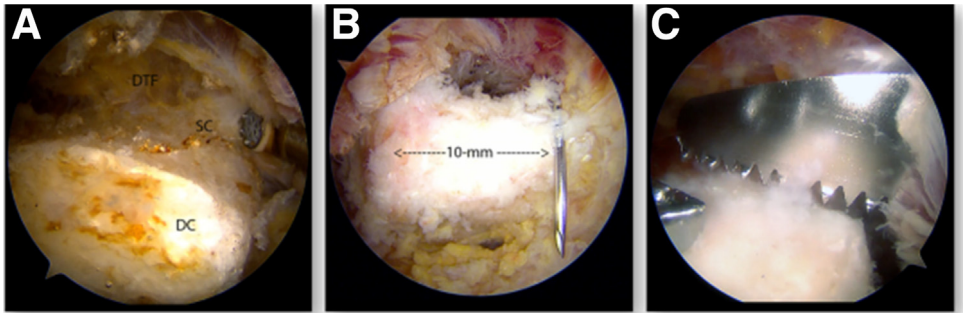

Fig 4. Distal clavicle exposure and osteotomy. Intraoperative images of the right distal clavicle. (A) Lateral view of the distal clavicle (DC) after subperiosteal dissection. The superior capsule (SC) and the deltoid-trapezial fascia (DTF) are preserved to prevent any lateral instability of the acromioclavicular joint. (B) View of the distal clavicle from the anterolateral portal with a spinal needle, to visualize the osteotomy line; usually, a 10-mm bone graft is sufficient to reconstruct up to 30% glenoid bone loss. (C) A high-speed oscillating saw is used to perform a slightly oblique osteotomy of the distal clavicle under arthroscopy.

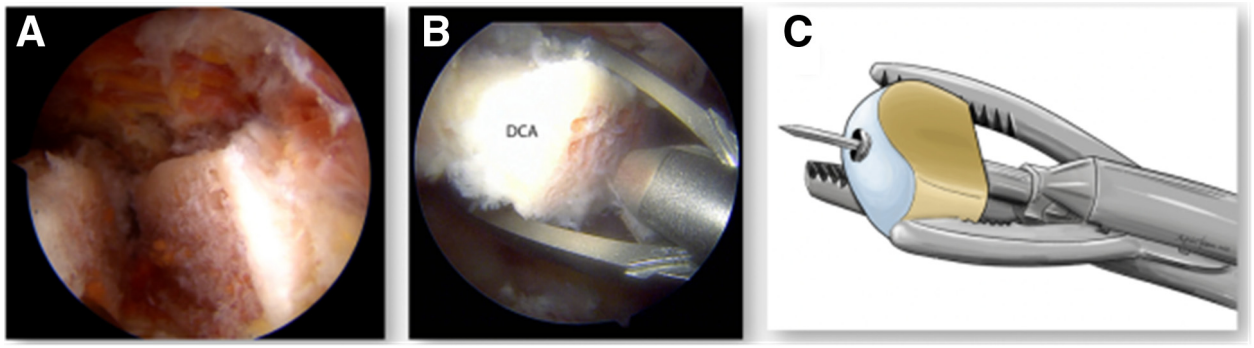

Fig 5. Distal clavicle autograft drilling. (A) Arthroscopic anterolateral view of the osteotomy of the distal clavicle completed. (B and C) A specific 3-arms guide (Smith and Nephew) introduced from the anteromedial portal is used to clamp the DCA and drill bit across the bone block.

Step 4: Clavicle Bone Graft Transfer and Fixation

The PDS lead suture is passed through the rotator interval, with the help of a grasper, and a suture-retriever is passed through the cannulated sleeve of the glenoid, to catch the PDS. Once the PDS suture is exteriorized posteriorly, the glenoid outer sleeve is removed. The PDS suture will be used to shuttle the suture tail ends of the peg button implant (Bone-Link) through the bone block and the glenoid (Fig 6).

The posterior button is then slid along the loop suture, and a sliding-locking knot (Nice knot)[30] is tied at the back of the shoulder. Gentle traction is applied on the posterior sutures, bringing the posterior button in contact with the cortex of the posterior glenoid neck; in the meantime, a grasper is used to direct and guide the graft through the rotator interval.

The position of the graft is crucial. The DCA is placed with its cancellous side facing the anterior glenoid neck,

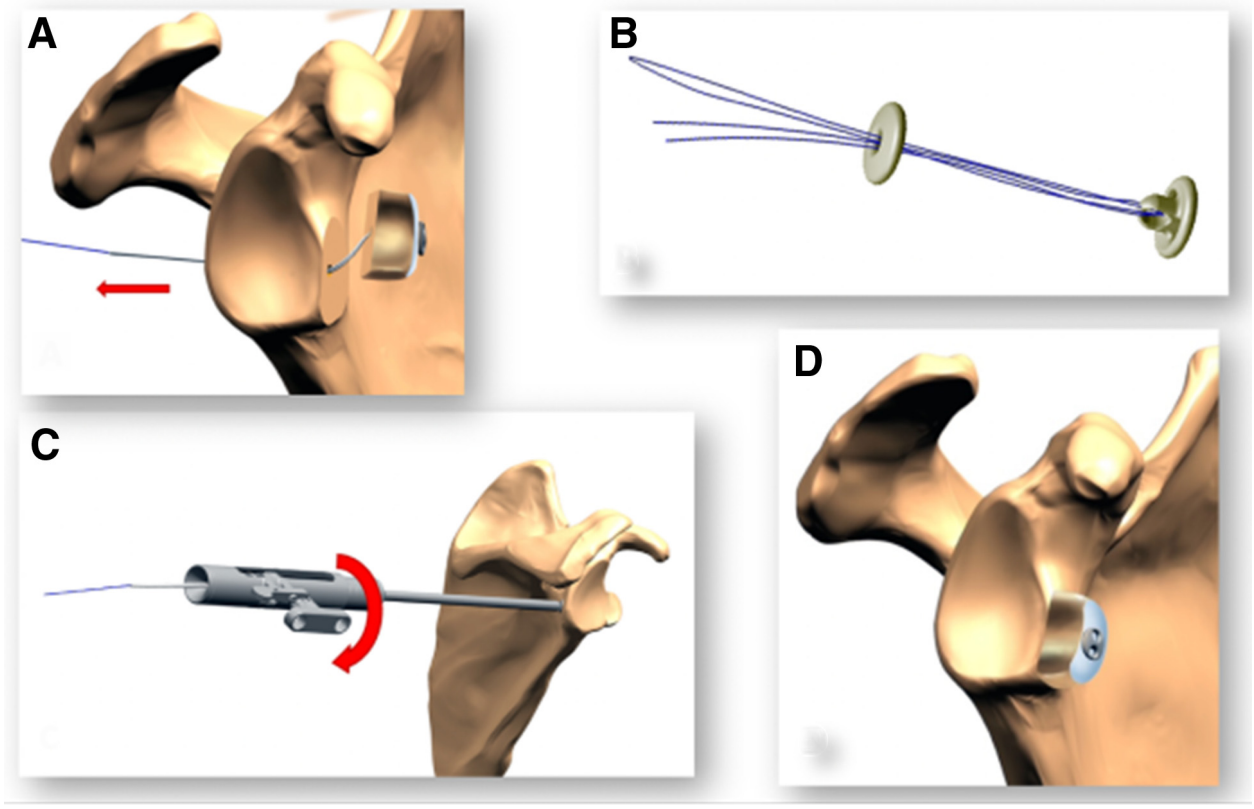

Fig 6. Distal clavicle autograft transfer and fixation. (A) Traction is placed on the suture at the back of the shoulder, in order to pass the bone block through the rotator interval and bring it on the anterior glenoid rim. (B) The posterior button is slide along the suture, exiting posteriorly and a sliding-locking knot (Nice knot) is performed. (C) A tensioning device from posterior portal is used to rigidify sutures and put compression on the bone graft. (D) The underside of the clavicle bone block is facing laterally so as to use the natural concavity od the graft on the articular side, thus creating a congruent construct.

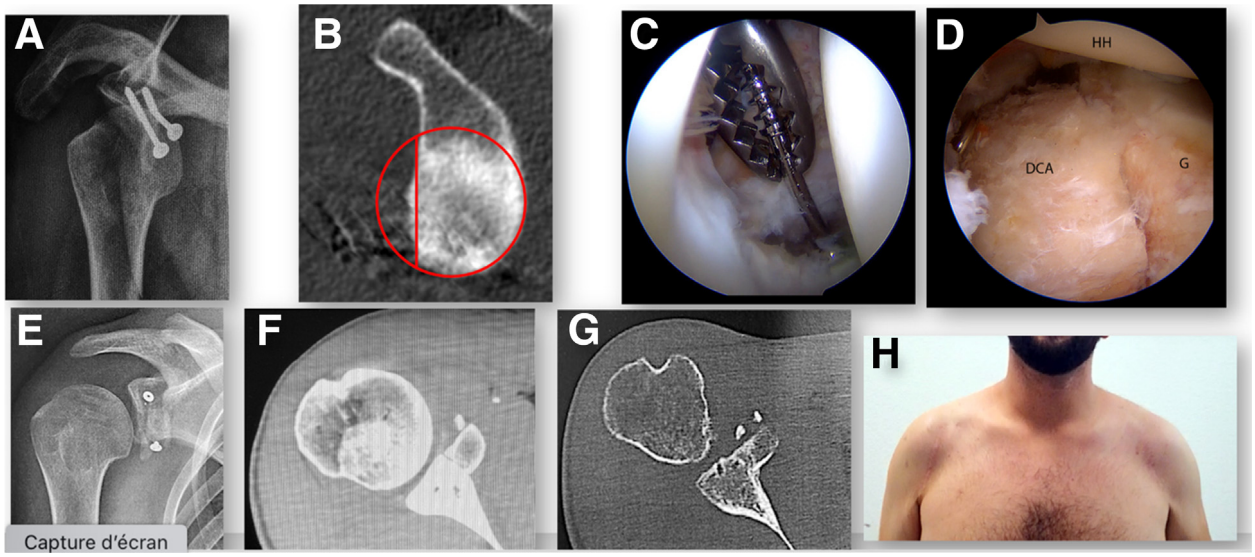

Fig 7. Clinical illustration in a 30-year-old man with 2 previous failed stabilization procedures (failed arthroscopic Bankart and failed open Latarjet). (A) Anteroposterior radiographs showing a recurrence of anterior dislocation with bended screws and coracoid bone block lysis. (B) CT scan with sagittal view showing significant (25%) loss of anteroinferior glenoid rim. (C) Arthroscopic view showing screws removal. (D) Final arthroscopic view showing DCA flush with the glenoid surface (G) and no impingement with humeral head (HH). (E) Postoperative radiograph showing glenoid reconstruction after screws removal and cortical button fixation of the arthroscopically DCA. (F-G) Postoperative axial 2-dimensional CT scan view showing perfect positioning of the bone graft (flush to the glenoid surface) and use of the concave underside of the clavicle to recreate the articulation with a "congruent construct." (H) Patient seen at 1-year follow-up with normal aspect of the shoulder, without any migration of the distal clavicle, donor-site pain or instability. (CT, computed tomography; DCA, distal clavicle autograft.)

and its underside facing laterally. This position allows to have the natural concavity of the graft on the articular side, creating a "congruent construct." Using a probe, the graft is placed flush with the articular glenoid surface.

Intraoperative bone graft compression is achieved with the help of a suture tensioner applied to the peg button implant. The tensioner is used posteriorly 3 times, up to a force of 100 Newtons: one to remove suture creeping, one to tight knots and one to provide graft compression.

The tensioning device is removed, and 3 additional square knots are tied to lock the construct. Suture-ends are cut short with an arthroscopic suture cutter. At the end of the procedure, the bone graft is securely positioned on the anterior glenoid, flush to the articular cartilage and below the equator.

Step 5: Bankart Repair

Once the graft is firmly fixed in place, the labrum is reinserted to the native glenoid rim with the 2 suture anchors previously inserted. The Bankart repair places the graft in an extra-articular position.

Arthroscopic DCA is routinely performed as an outpatient procedure. Postoperative indications are similar to the Latarjet, with neutral rotation sling for 2 weeks and immediate pendulum exercises (Video 1 and Fig 7).

Discussion

Our modified DCA technique uses the undersurface of the clavicle, which is concave, instead of its distal cartilaginous surface, which more often is convex. We do that to build a "congruent arc construct." The procedure is all-arthroscopic, and we use drilling guides to optimize

Table 2. Advantages and Disadvantages

Advantages	Disadvantages
• The procedure is all-arthroscopic, to optimize bone graft placement and increase safeness.	• Lack of articular cartilage of the "congruent arc" DCA
• The use of cortical buttons, to simplify graft transport, eliminates risk of hardware and neurologic complications.	• The "sacrifice" of the distal clavicle such as autograft, which is a normal anatomical structure.
• Drilling of the glenoid from posterior to anterior allows staying inside the glenohumeral joint and eliminating risk of neurovascular complications, avoiding work close to the brachial plexus.	

DCA, distal clavicular autograft.

bone graft placement, increasing the safeness.[26,29] We fix the clavicular graft with 2 cortical buttons and use a tensioning device (applying 100 Newtons) to rigidify the suture-button construct, thus ensuring intraoperative graft compression and increasing chances of bony consolidation.

Our procedure is similar to the congruent arc variant of the Latarjet procedure, in which the coracoid is rotated to match precisely the curvature of the glenoid. We think our procedure shares the same advantages.[31-36] In addition, the inferior surface of the clavicle is wider than the distal articular surface; potentially, this can make native glenoid surface larger. This is important, as the amount of bone graft resorption is more frequent in free bone grafts compared with coracoid grafts, which are vascularized.[7,28,37]

The use of cortical buttons simplifies graft transport, providing a safer and more reliable alternative fixation technique that has proven to be biomechanically sound.[17,38,39] Cortical-button fixation eliminates the risk of hardware and neurologic complications related to screws.[20–23,25] It facilitates revision surgery, mostly in case of remaining broken screws in the glenoid vault.[28,40] Moreover, the use of a posterior glenoid drilling guide virtually eliminates the risk of neurovascular complications, avoiding work next to the brachial plexus, through a far medial transpectoralis portal.[27,28] The risk of iatrogenic fracture of the graft is minimized, as only one hole is drilled instead of 2 for screw fixation. The hole we drill is 2.8 mm in diameter, smaller than the 3.5-mm holes for the screws.

A potential disadvantage of the "congruent arc" DCA is the lack of articular cartilage. However, we systematically perform a Bankart repair, placing the graft in an extra-articular position and preventing direct contact between the humeral head and graft. Recent studies suggest that a fibrous or pseudo-cartilaginous joint surface develops on the articular surface of bone autografts.[41]

Another potential disadvantage is the "sacrifice" of a normal anatomical structure for DCA. However, there are surgical procedures that commonly resect the distal clavicle, such as the Mumford procedure,[42] to treat symptomatic AC degeneration or AC joint dislocation grade 1 or 2. They mention no site morbidity.[43-45]

Advantages and disadvantages of the surgical technique are summarized in Table 2.

In conclusion, "congruent arc" DCA allows restoration of large glenoid bone defects (>25%). Our early experience has encouraged us to prefer DCA than iliac crest bone graft for treating shoulder instability with glenoid bone loss after failed Latarjet or Eden–Hybbinette.

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