Functional Coracoclavicular Stabilization for Acute Acromioclavicular Joint Disruption

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This article presents a coracoclavicular functional stabilization technique to restore the anteroposterior and vertical displacement of the disrupted clavicle and thus facilitate early joint motion and final shoulder function.

Various operative techniques have been proposed for the treatment of complete (Rockwood type III-VI) acromioclavicular joint disruption, including dynamic muscle transfer, acromioclavicular joint fixation, and coracoclavicular loop or cross-screw reconstruction with or without supplementary excision of the distal end of the clavicle. To avoiding the potential complications of hard material use, we developed a coracoclavicular functional stabilization technique to restore the anteroposterior (AP) and vertical displacement of the disrupted clavicle and thus facilitate early joint motion and final shoulder function.

The procedure involves exposure of the distal clavicle by a strap incision and passage of 2 pairs of nonabsorbable heavy sutures beneath the coracoid process as close as possible to its base. A 4.5-mm drill hole to the distal clavicle is then created, and one limb of each pair of sutures is passed through in front and back of it to control AP and vertical displacement (Figure 1, left). After reduction of the dislocation in both directions, the sutures are knotted tightly to the clavicle (Figure 1, right), the adequacy of the repair is assessed, and the underlying sutures are completely covered by the musculocutaneous flaps.

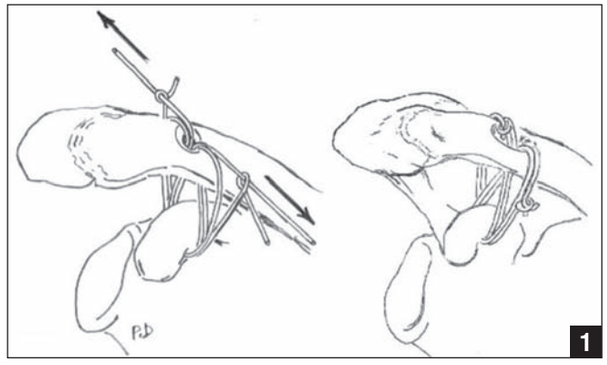

Figure 1: Schematic representation of the coracoclavicular functional stabilization technique. Left: suture passage and control of anteroposterior displacement by applying equal force to different directions. Right: knotting of the sutures and final appearance of the reconstruction.

Surgical Technique

General or regional anesthesia by interscalene block is administered. Three doses of a second-generation cephalosporin are usually administered for infection prophylaxis. The patient is placed in the beach-chair position with at least 60° of flexion at the waist and two folded sheets behind the scapula to bring the shoulder girdle forward and facilitate access to the superior portion of the joint. The entire upper extremity is prepared and draped to allow full and unrestricted arm positioning during the procedure.

A "strap" skin incision is designed based on the standard anatomic landmarks: anterior portion of the acromion, distal clavicle, and coracoid process. It starts 2-3 cm posterior to the acromioclavicular joint and is extended to the tip of the coracoid process. The incision is carried down longitudinally through the subcutaneous tissues, in line with the superior cortex of the clavicle. Full-thickness soft-tissue flaps from the anterior deltoid and

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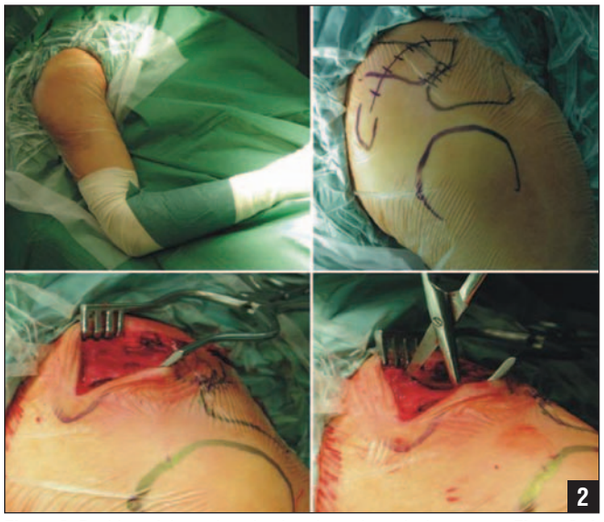


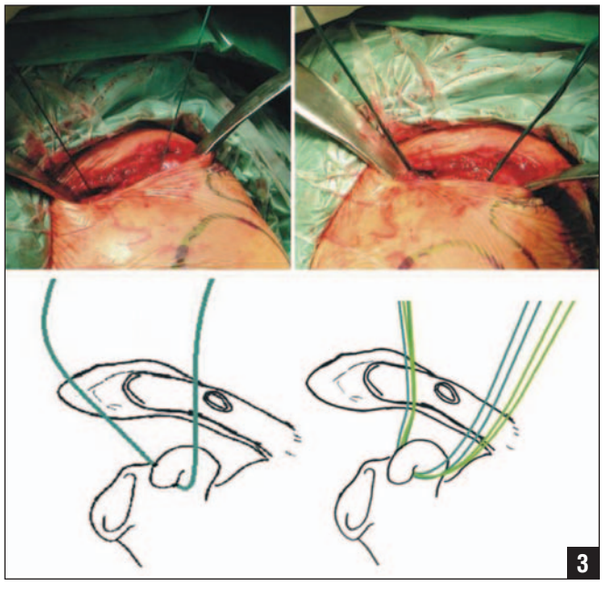


Figure 2: Position of the patient, landmarks and surgical exposure. **Figure 3:** A curved suture passer directs the guide suture around the base of the coracoid process. This suture is used to pass four Ethibond Excel No 5 non-absorbable sutures for the coracoclavicular stabilization.

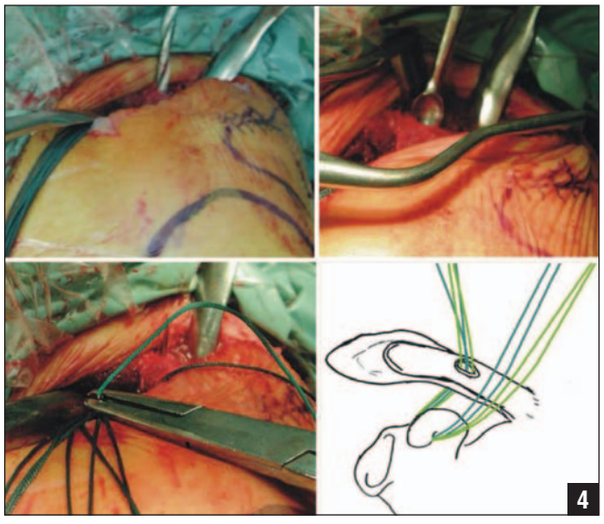
posterior trapezius must be prepared to ensure an adequate soft-tissue envelope for closure (Figure 2). The anterior deltoid is split in line with its fibers, approximately 2 cm distally towards the tip of the coracoid process to facilitate its exposure. A curved soft-tissue elevator is used to bluntly dissect the tissues medially and laterally for suture passage around the coracoid process. A curved suture passer directs the guide suture around the base of the coracoid process. This suture is used to pass 4 Ethibond Excel No 5 (Ethicon, Johnson & Johnson Intl, Somerville, NJ) nonabsorbable sutures for the coracoclavicular stabilization. The sutures are passed from a medial to lateral direction beneath the base of the coracoid and must be placed as close as possible to its base; this becomes easier by pulling their ends back and forward in a sawing motion (Figure 3).

Next the clavicle is prepared and a hole is opened through the superior cortex with a 4.5-mm drill placed in the center of the clavicle, 2 cm proximal to its distal end, at the corresponding insertion of the coracoclavicular ligaments. All 4 sutures are first passed through the clavicular hole using the incorporated needles (Figure 4); 2 of them will be used for the anterior retention of the clavicle and are kept apart. The other pair of sutures is passed behind the clavicle with a free needle that is advanced as close as possible to the inferior border of the distal clavicle. This is the most important step of the procedure. The surgeon holds the 2 pairs of sutures in opposite directions, anteriorly and posteriorly, being able to correct any existing AP displacement of the clavicle, while the assistant reduces the dislocated clavicle with a blunt instrument. The clavicle is held in the reduced position and each pair of sutures is tied off (Figure 5). It is important to maintain the clavicle in a slightly over-reduced position as the sutures are tied off and also to make the knots near or beneath the anterior and posterior edges of the clavicle.

The adequacy of the reduction is then assessed. Just prior to closure the arm is put through a complete range of motion (ROM) to assess the security of the repair. If any concern exists, revision to a more secure fixation should be performed at this time. Suction drain placement is not usually necessary except for rare cases with significant bleeding. The anterior deltoid and posterior trapezius flaps are reapproximated over the superior aspect of the lateral clavicle using absorbable sutures. The repair should be secure and the underlying sutures completely covered. Placing the knots away from the superior aspect of the clavicle facilitates this. The subcutaneous tissue is closed with absorbable sutures and the skin intracutaneously. A Velpeau dressing converted to a simple sling at the second postoperative day secures the arm to the chest wall.

REHABILITATION

The dressings are removed on the second postoperative day along with the suction drain, if present. Rehabilitation initially consists of active ROM exercises for the elbow, wrists, and hand. The patient is discharged 2 days postoperatively and is guided to perform passive and active-assistive shoulder exercises with forward elevation limited to 90°, external rotation to 30°, and internal rotation allowed only to the chest wall. Forward elevation is limited to 90° to minimize clavicular rotation that



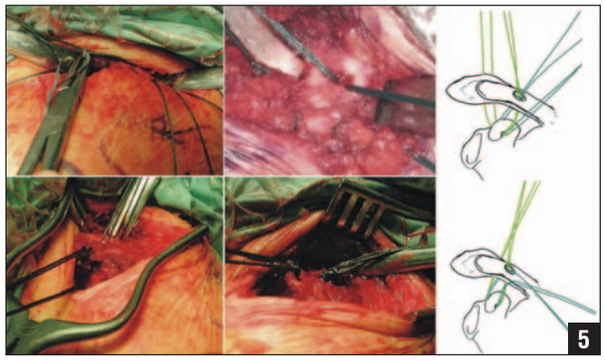


Figure 4: The clavicular hole is prepared with a 4.5 mm drill, through its superior cortex, placed in the center of the clavicle, 2 cm proximal to its distal end. The edges of the hole are smoothened with a small curette. All four sutures are first passed through the clavicular hole using the incorporated needles. **Figure 5:** A free needle is used for the passage of two sutures behind the clavicle. The needle must be advanced carefully as close as possible to the inferior border of the clavicle. The surgeon holds the two pair of sutures in opposite directions and can correct the anteroposterior displacement of the clavicle while the assistant reduces the dislocated clavicle with a blunt instrument. The clavicle is held in the reduced position and each pair of sutures is tied off.

may compromise the repair. Range of motion is advanced at 4 weeks, and the sling is discontinued at 6 weeks. Following sling removal, active ROM exercises are started. These are performed in a supine position until full active ROM is regained. A strengthening program is started thereafter, including isometric exercises with progression to resistive exercises. Heavy lifting or any other activity that would result in significant downward traction on the upper extremity is avoided for 3 months postoperatively. Strenuous use of the arm, including significant athletic activity, is not advised until 4-6 months postoperatively.

Clarifications, Potential Complications, and Clinical Relevance

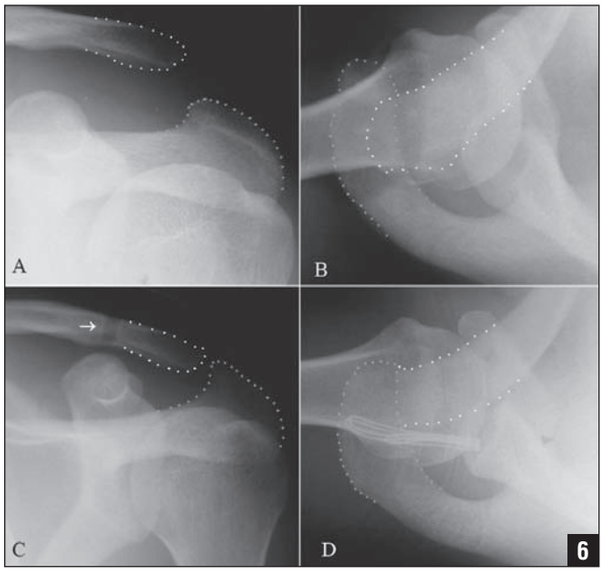
In our Shoulder Unit we are adherents of operative reconstruction for acute acromioclavicular joint disruption (types III-VI according to Rockwood's classification[1]). In the lack of prospective comparative studies between surgical and conservative treatment of these injuries, the only relevant sources for good practice are several retrospective studies with small numbers of patients and a few meta-analyses that compare conservative treatment with different operative techniques of reconstruction. We believe that the controversial results of the existing surgical techniques are more due to the techniques themselves than to the decision of operative intervention.

So far, 38 patients (34 men and 4 women, average age 33.5 years old) have been treated with the proposed technique by the senior surgeon (P.D.). All of our patients had type III or IV acromioclavicular separation and were semi-professional or professional athletes or heavy manual labors, but the technique can be applied in every active patient who desires normal shoulder function. Old separations that present with pain or marked deformity also can be treated with the proposed technique, but osteotomy of the distal 1 cm of the clavicle usually is required. Vascular or neurological complications were not identified. Thirty-four patients were available for clinical and radiological assessment in a mean follow-up period of 33.2 months (range: 18-59 months).

The mean Constant-Murley Score was 91.7 points (range: 72-98 points) and 1 patient had moderate acromioclavicular joint tenderness by manual testing. As he was a semi-professional basketball athlete, he abandoned sport activities but returned to his prior occupation. No deep infections were noted except in 1 patient who had a superficial soft-tissue infection that was easily managed with oral antibiotics. A 61-year-old patient had restricted shoulder motion 28 months postoperatively but his physical activity level was already reduced prior to the injury as indicated by his low functional Constant-Murley score (69%) in comparison with the unaffected shoulder. Radiological evidence of post-traumatic acromioclavicular joint degeneration was not detected. Slight loss of reduction was noted in 2 patients, but their functional outcome was good and they had no acromioclavicular tenderness on manual testing. Thirty-two patients (94%) maintained reduction of the acromioclavicular joint in both anteroposterior and vertical plans (Figure 4). The incidence of eterotopic ossification was very low (17.6%) and did not affect the final outcome.

Discussion

Ideal treatment of type III acromioclavicular joint disruption remains controversial, with a trend in most series towards nonoperative management.[1-4] Prospective studies



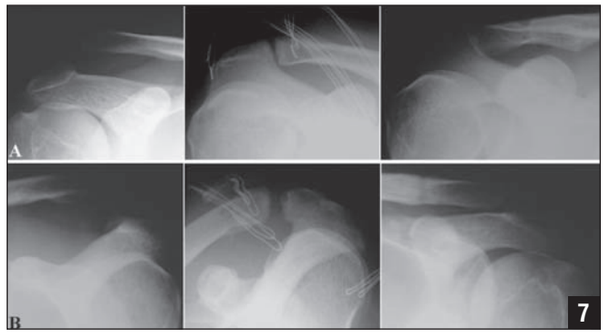


Figure 6: Preoperative (A,B) and postoperative (C,D) radiographs of a complete acromioclavicular joint separation treated with the proposed technique. Adequate reduction can be achieved in both anteroposterior and vertical planes. The white arrow indicates the drill hole in the distal clavicle. **Figure 7:** Two cases of type III AC joint separation treated with our technique and the maintenance of reduction after 3.2 (A) and 4 (B) years after the operation. Note that there were not evidences of either eterotopic ossification or posttraumatic osteoarthritis.

comparing nonoperative and surgical treatment of these injuries have shown similar results with no great advantage of either treatment.[5,6] Some patients, however, particularly those involved in overhead sports or heavy manual labor, may develop pain and mechanical symptoms interfering with their ability to perform their usual sport or job. The disruption of the synchronous scapuloclavicular motion that normally occurs with overhead activity is the main cause of this disability and has led some authors to recommend surgical repair or reconstruction.[7-9]

Various operative procedures have been described for the treatment of complete acromioclavicular joint injuries, including dynamic muscle transfers, acromioclavicular joint repairs, excision of the distal clavicle with coracoacromial ligament reconstruction, coracoclavicular stabilization, reconstruction with tendon grafts and arthroscopic reduction of the dislocation. The goal of these procedures is to reduce the dislocation and create an environment for soft-tissue healing and stabilization of the distal clavicle. It is uncertain, however, whether current surgical techniques restore normal anatomy to allow return to unimpeded repetitive overhead activity.

Transfer of the tip of the coracoid process together with the attached conjoined tendon (they act as dynamic depressors of the clavicle) has been described by various authors.[10,11] This major procedure bypasses the site of pathology and appears to involve more risks than necessary, such as injury to the musculocutaneous nerve, nonunion of the transferred coracoid, and loss of fixation or screw breakage. As this procedure does not provide static stability, continued motion and subsequent pain at the acromioclavicular joint persist.

Fixation across the acromioclavicular joint with wires, pins, screws, or plates has also been reported.[12-15] These procedures usually are combined with repair or reconstruction of the acromio- or coracoclavicular ligaments. With concern over pin migration, breakage,[16] and fixation failure, this procedure has fallen out of favor. Re-approximation of the disrupted acromioclavicular joint with hardware may lead to further damage to the articular cartilage and meniscus, resulting in degenerative arthritis of the acromioclavicular joint.[7] Percutaneous or blind pinning of the acromioclavicular joint is another accepted technique, but it does not allow coracoclavicular ligament repair, deltoid and trapezius reattachment (fascial repair), or acromioclavicular joint debridement.[15]

Reduction of the acromioclavicular joint can be achieved, according to the Bosworth technique,[17] by a specially designed screw with a low-profile head that is inserted through the clavicle into the base of the coracoid process. The initial recommendation did not include repair or reconstruction of the ligaments. Rockwood et al[1] popularized the Bosworth technique along with repair of the ligaments for acute injuries requiring operative treatment; for chronic injuries, however, they recommended only reconstruction of the ligament. The screw unloads the repair during healing but it is removed between 8-10 weeks postoperatively as soon as the coracoclavicular ligaments have healed. Common complications include ossification between the coracoid and the clavicle, osteolysis, loosening, and screw breakage.

In 1972, Weaver and Dunn[18] described a technique to treat acute and chronic acromioclavicular joint dislocations. The procedure involves transfer of the coracoacromial

ligament into the distal end of the clavicle after approximately a 10- to 12-mm resection has been accomplished. While this is a very popular procedure, it has been shown that the transferred coracoacromial ligament alone does not approach the strength of an intact coracoclavicular ligament or coracoclavicular screw and additional augmentation has been recommended (such as sutures, tapes, or screws) to keep the acromioclavicular joint reduced while the ligament transfer heals.[8,19,20] A common criticism of this technique is that the clavicle is placed in a nonanatomic position. Numerous complications have been reported with this method, including hardware migration, fracture, infection, and fixation failure. We also believe that in sacrificing the coracoacromial ligament, the restraining mechanism that alters the humeral head's upward migration is compromised. Moreover, the potential existence of a synaptic connection between coracoacromial mechanoreceptors and shoulder muscles may lead to imbalance of muscle coordination and functional joint stability.[21]

Several authors have proposed various "cerclage or loop" techniques to fashion a coracoclavicular loop that tethers the coracoid to the clavicle using wires, sutures, Dacron or mersilene tapes, or other synthetic loops of absorbable or nonabsorbable material.[22-25] The loop is usually passed around the base of the coracoid and then through a drill hole in the clavicle or around the clavicle itself. These materials perform well in biomechanical studies but have posed some problems with erosion through the distal clavicle and infection.[26-28] Also if the fixation loop is not accurately placed at the subcoracoid position, it tends to displace the clavicle anteriorly.[29] In other words, they reduce the vertical separation of the clavicle away for the acromion, but they do not restore the horizontal alignment of the acromioclavicular joint. Furthermore, if the loop of material is passed over the top of the clavicle, it may erode through its lateral end and produce a fracture.

The main advantage of our technique is that the surgeon can control both AP and vertical displacement, placing the clavicle at its anatomical position and allowing the disrupted coracoclavicular and acromioclavicular ligaments to heal easily (Figure 3). The "sawing" effect of the sutures is minimized by the smoothing of clavicular hole edges with a curette and also by the fact that an equal tensioning force is applied to both the anterior and posterior border of the distal clavicle during knotting.

Techniques of autogenous tendon graft reconstruction have also been reported.[30] Lee et al[31] found that there wasn't any statistical difference in load-to-failure among three tendon grafts tested (gracilis, toe extensors, and semitendinosus). They also found that stiffness after the suture and tape repairs was not significantly different from that after the tendon graft reconstruction. Mazzocca et al[32] proposed a modification of these existing techniques and placed them in an "anatomic" position. They tried to fully reconstruct the coracoclavicular syndesmosis by making 2 bone tunnels in the clavicle in as accurate a position as possible to recreate the coracoclavicular ligaments; the posterior tunnel recreates the conoid ligament and the central tunnel recreates the trapezoid ligament. The graft can be secured both to the coracoid and the clavicle either by the loop technique or using the interference screw-fit technique. Despite the fact that an anatomic reconstruction can be achieved by these methods, these procedures are technically demanding, do not avoid hard material application, sacrifice a normal tendon, and have the potential of complete failure due to non-healing of the ligament grafts.

Finally, less invasive arthroscopic methods of acromioclavicular joint reconstruction have been reported recently,[33,34] aiming for rapid rehabilitation and cosmetically pleasing results. Arthroscopic acromioclavicular joint reconstruction is a reproducible, nearly percutaneous technique but is only well suited for orthopedic surgeons with experience in arthroscopic shoulder surgery. In one study,[35] 19% of the patients had poor results; the failures were thought to be secondary to erosion of the coracoid bone by the sawing action of the suture material.

Conclusion

The proposed anatomic method of coracoclavicular functional stabilization seems to be a promising alternative operative procedure for acute acromioclavicular joint separations. The minimally invasive characteristics and the simplicity of our technique can restore the damaged anatomy without sacrificing any tendons or ligaments. Controlling both the vertical and AP displacement of the clavicle by using 2 different pairs of sutures placed in the exact anatomic position of the disrupted coracoclavicular ligaments allows us to bypass the main disadvantage of other coracoclavicular loop techniques – the anterior displacement of the distal clavicle. There is also no need for hardware application, thus eliminating the potential dangers of pin migration, breakage, infection, screw loosening, and re-operation for material removal.

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