

# ACROMIOCLAVICULAR JOINT INSTABILITY—RECONSTRUCTION INDICATIONS AND TECHNIQUES

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Injuries to the acromioclavicular joint are common and may lead to instability or degenerative changes requiring surgical intervention. The spectrum of injury ranges from sprain to disruption of the acromioclavicular and coracoclavicular ligaments, which provide horizontal and vertical stability to the distal clavicle. Most injuries are the result of direct trauma to the acromioclavicular joint. The majority of injuries can be nonoperatively managed. However, with significant disruption to the surrounding supportive structures, painful instability may result. Multiple stabilization procedures for the acromioclavicular joint have been described. Many of these techniques have fallen out of favor due to high complication rates. Common reconstruction techniques include either coracoclavicular ligament reconstruction with or without clavicle resection (ie, modified Weaver-Dunn) or coracoclavicular stabilization (ie, with Bosworth screw) with repair or reconstruction of the coracoclavicular ligaments. The purpose of this paper is to review the basic anatomy, biomechanics, and treatment of acromioclavicular joint instability.

**KEY WORDS:** acromioclavicular (AC) joint instability, modified Weaver-Dunn

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## ANATOMY

An understanding of the acromioclavicular joint anatomy is fundamental to understanding injuries and surgical treatments of this joint. The acromioclavicular joint is a diarthrodial joint between the clavicle and acromion and helps to link the shoulder to the axial skeleton. The joint is palpable on examination as a shallow depression between the end of the clavicle and the acromion. The articulation between these two bones can form at highly variable angles. The sides of this joint are covered with articular cartilage, with a fibrocartilagenous disk in between which is often referred to as a meniscal homologue. The degree of disk completeness varies, with only 10% of individuals having a complete disk.<sup>1,2</sup>

Stability to this joint is provided through two sets of ligaments—the acromioclavicular (AC) and coracoclavicular (CC) ligaments. The acromioclavicular ligaments are horizontally directed and function to control horizontal (anteroposterior) stability for the acromioclavicular joint.<sup>2,3</sup> In addition to the joint capsule, the acromioclavicular ligaments intimately surround the joint and are divided into superior, inferior, anterior, and posterior components. The superior ligament is the largest of the four components and is the primary acromioclavicular joint stabilizer for normal daily activities. The acromioclavicular ligaments attach to the clavicle approximately 1.5 cm from the joint.

Excision of 1.5 cm or more of the distal clavicle may result in disruption of the acromioclavicular ligaments and lead to horizontal instability of the acromioclavicular joint.

The coracoclavicular ligaments are the stronger, more vertically oriented ligaments that have two components, the conoid and trapezoid ligaments. The conical shaped conoid ligament is more medial and is the most important ligament for support against injuries and superior (vertical) displacement of the clavicle in relation to the acromion.<sup>3,4</sup> This ligament runs from the conoid tubercle of the clavicle to the base of the coracoid process. The more laterally based trapezoid ligament lies anterior and lateral to the conoid tubercle and inserts more laterally on the base of the coracoid. This ligament primarily functions to resist compression across the acromioclavicular joint. The average insertional distance of the conoid ligament from the acromioclavicular joint is 28.9 mm in females and 33.5 mm in males. The insertional distances for the trapezoid ligament are 16.1 and 16.7 mm from the joint in females and males, respectively. The clinical relevance in these distances is found in the facts that a resection of less than 11 mm does not violate the trapezoid ligament insertion and a resection of less than 24 mm should not disrupt the insertion of the conoid ligament in either gender in 95% of patients.<sup>5</sup>

Minimal motion, between 5 and 8°, occurs through the acromioclavicular joint.<sup>6</sup> This is due in part to the synchronous motion between the clavicle and scapula. Clinically this is supported, with acromioclavicular joint fusions resulting in little dysfunction.<sup>7</sup>

## DIAGNOSIS

The history, physical examination, and radiographic findings all help to accurately diagnose the severity of an acromioclavicular joint injury.

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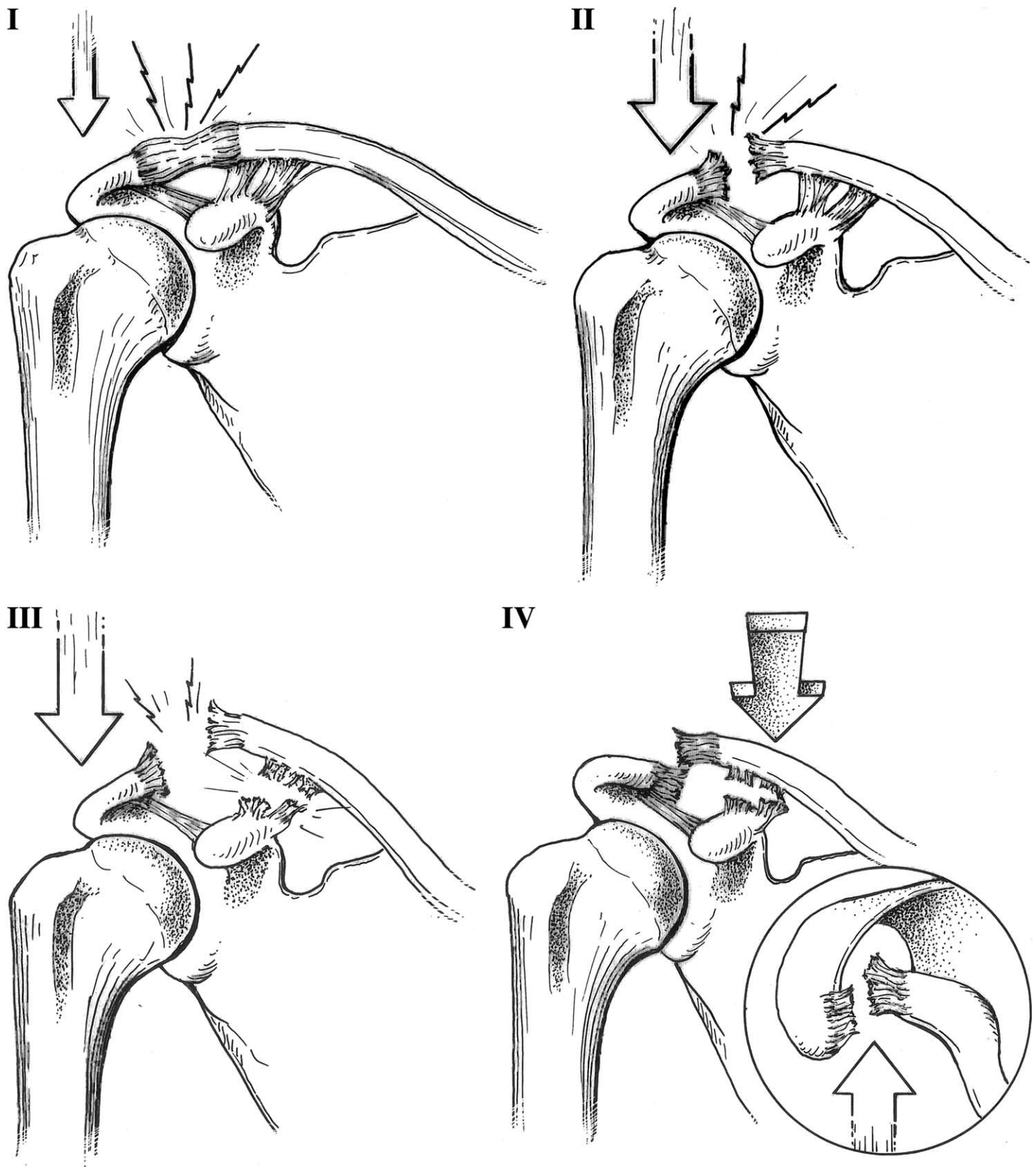


Fig 1. Classification for acromioclavicular joint injuries Types I-VI.

**CLASSIFICATION**

The traditional classification of three types of acromioclavicular joint injuries was expanded to six by Rockwood in 1984.<sup>6,8,9</sup> This current classification system is almost universally used and is based on the degree and direction of disrupted anatomy (Fig 1). Briefly, a Type I AC joint injury is a strain to the acromioclavicular ligament and no sig-

nificant instability is present. Type II reveals a complete tear of the acromioclavicular ligaments, but the coracoclavicular ligaments remain intact. There may be slight vertical separation of the acromioclavicular joint. In Type III, IV, and V AC joint separations, both sets of ligaments are disrupted. A Type III occurs when the distal clavicle is completely displaced. In a Type IV injury there is posterior

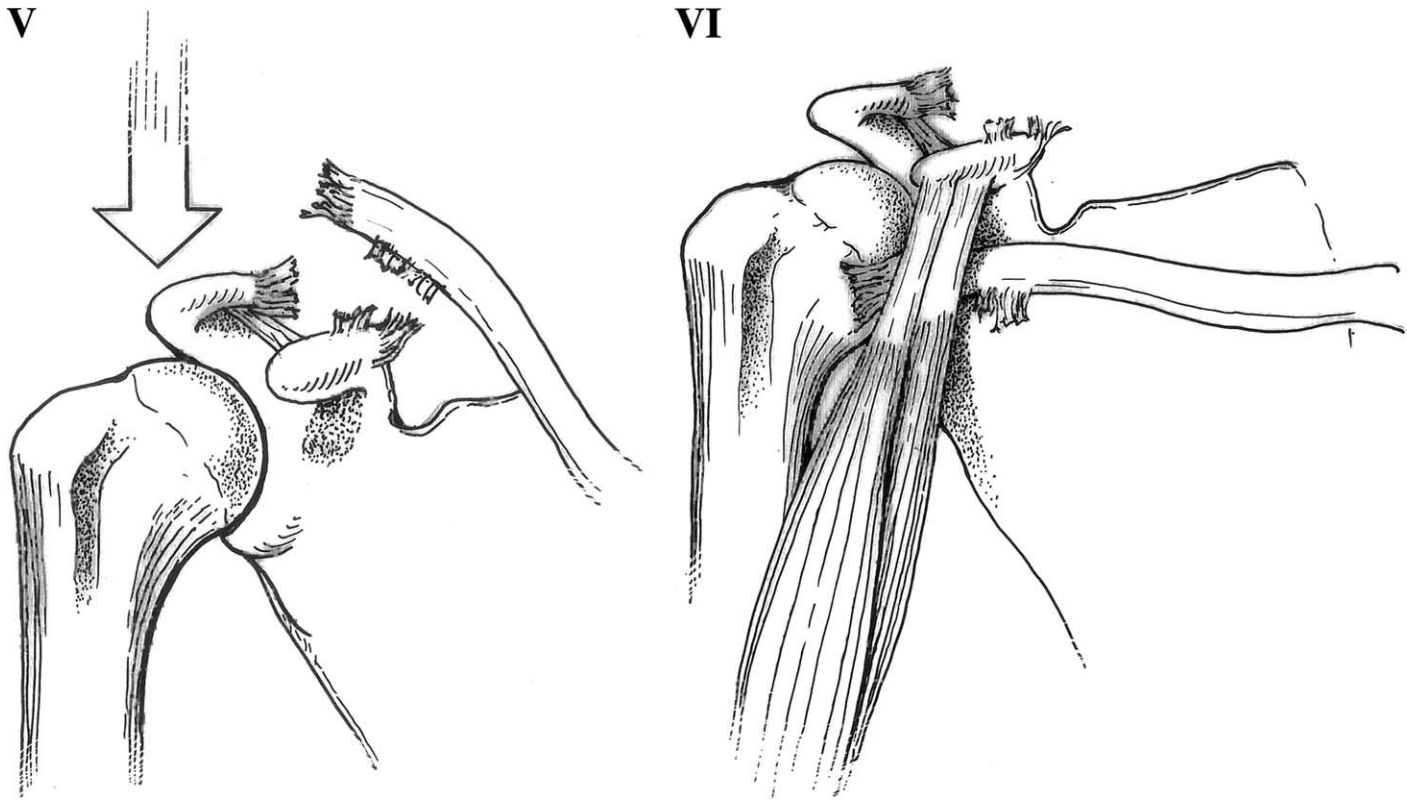


Fig 1. (cont'd)

displacement of the clavicle through the trapezius muscle. In the Type V AC joint separation gross displacement, often between 100 and 300% of the width of the clavicle is present. Finally, in a Type VI injury the distal clavicle is inferiorly displaced, to be either subacromial or subcoracoid. In the subacromial Type VI injury the coracoclavicular ligaments are preserved, while in the subcoracoid variant the coracoclavicular ligaments are torn. In Type III-VI injuries, the deltoid and trapezius muscles are detached from the distal clavicle.

The characteristic history for an acromioclavicular joint injury is a direct blow to the lateral shoulder. This frequently occurs from a fall with an adducted arm, as in falling off a bicycle or a horse. Rarely, a fall on an outstretched arm or flexed elbow may cause a superiorly directed force through the humeral head to the acromion resulting in an acromioclavicular injury. The severity of injury is based on the direction and degree of forces across the joint. The acromioclavicular ligaments typically are injured first, with the coracoclavicular ligaments being disrupted with more significant force.<sup>7</sup> The most common sports associated with acromioclavicular joint injuries include bicycling, skiing, hockey, rugby, and football.

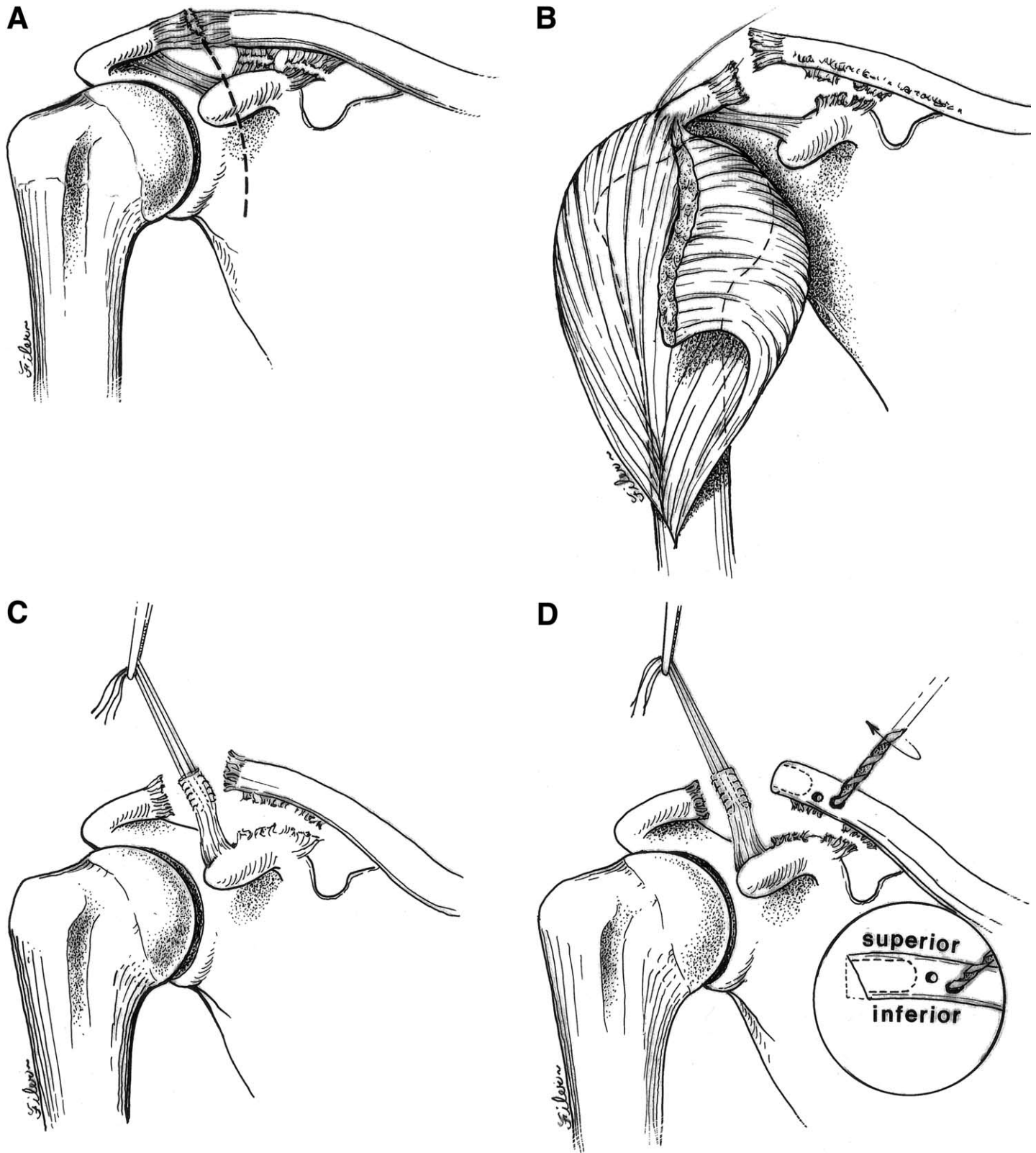
The physical examination is notable for localized tenderness over the acromioclavicular joint, with or without an obvious deformity. The prominence of the acromioclavicular joint is due to the shoulder complex being displaced inferiorly. In Type V injuries, the marked prominence of the clavicle has been referred to as an "ear tickler" deformity. With acromioclavicular joint injuries there may also be a skin abrasion or irritation over the superior aspect of the joint secondary to the fall. Although glenohumeral motion is preserved, it is frequently decreased

secondary to pain. This is most notable with cross-body adduction or resisted abduction. The pattern of pain associated with acromioclavicular joint injuries has been demonstrated through a selective injection study showing pain radiating into the anterolateral neck, the trapezius-supraspinatus region, and the anterolateral deltoid as well as directly over the joint.<sup>10</sup> While infrequent, it is important to evaluate the entire shoulder to rule out additional injuries. This is particularly true for Type VI injuries which have been associated with rib fractures and pneumothorax and sternoclavicular joint injuries.

Preferred imaging studies include an AP view with a 50% decrease in penetrance with the X-ray beam tilted cephalad by 10 to 15°.<sup>11</sup> The decrease in penetrance prevents overexposure and the 15° cephalic tilt helps to remove the scapula from being superimposed onto the acromioclavicular joint. Additional radiographs include axillary and scapular outlet views. The axillary radiograph helps to show the position of the clavicle relative to the acromion. Stress radiographs to differentiate Type II and III injuries are no longer routinely recommended since they rarely influence treatment.<sup>12</sup>

## TREATMENT OPTIONS

The treatment is dictated by the type of injury. For all acute Type I and II injuries, nonoperative treatment with rest, immobilization (1 to 3 weeks), cryotherapy, and early motion is recommended. Early surgical stabilization of the acromioclavicular joint is indicated for acute Type IV-VI injuries.



**Fig 2. Technique of modified Weaver-Dunn coracoclavicular ligament reconstruction. (A) Incision, (B) deltoid taken down for exposure, (C) harvesting of coracoacromial (CA) ligament, (D) clavicle preparation, (E) passage of CA ligament into clavicle, (F) securing ligament transfer, (G) ligament transfer augment with absorbable suture, (H) final repair.**

The treatment of Type III acromioclavicular injuries remains controversial. The treatment pendulum has swung back and forth between nonoperative and operative treatment. Before the 1960s, conservative treatment was advocated.<sup>13</sup> In response to multiple reports of various surgical techniques, many orthopedic surgeons recommended sur-

gical management in the 1970s.<sup>14</sup> Over the past 2 decades the treatment pendulum has returned, advocating nonoperative management. In 1986, Larsen and coworkers reported a shorter rehabilitation time, decreased complications, and no difference in the end clinical result from nonoperative treatment in a prospective randomized

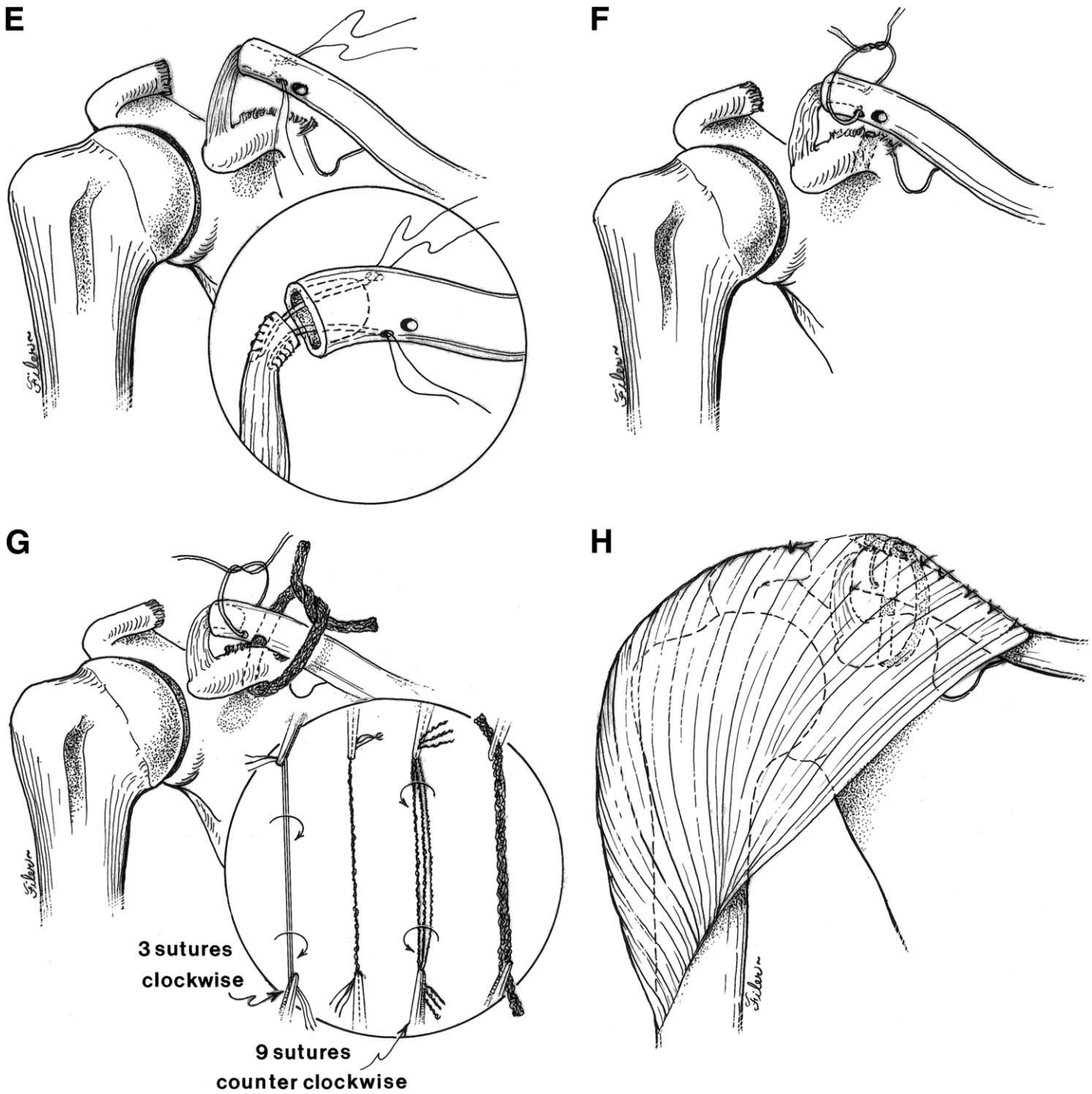


Fig 2. (cont'd)

study of 84 patients comparing nonoperative and operative (AC joint fixation with AC and CC ligament repair) treatments.<sup>15</sup> In another prospective randomized study comparing nonoperative to operative treatment, Bannister and coworkers in 1989 reported results comparing nonoperative and operative (coracoclavicular screw fixation and repair of the deltopectoral fascia) treatments in 54 patients.<sup>16</sup> At 4 years of follow-up, the conservatively treated patients had fewer unsatisfactory results and were able to return to full motion, work, and sports earlier than those who had surgery. Both studies, however, did suggest that exceptions to nonoperative treatment existed in patients involved with heavy work or those who had acromioclavicular

displacement greater than 2 cm. Tibone and coworkers reported in 1992 at an average of 4.5 years follow-up on 20 patients with Type III AC separations that there were no significant strength or range of motion differences between the injured side and the uninjured contralateral side.<sup>17</sup> Another insightful study is the natural history of untreated Type III injuries by Schlegel and coworkers.<sup>18</sup> In that study, 16 of 20 (80%) patients available for follow-up at 1 year were satisfied with nonoperative treatment. Only 1 of the 4 unsatisfied patients had significant enough complaints to choose surgery. In this study there was a short-term difference in bench press strength and there were no limitations in motion or sig-

nificant muscle strength differences at the 1-year mark. Recently, Phillips and coworkers published findings from a metaanalysis on outcomes of AC separations involving 1172 patients.<sup>19</sup> Their results showed nearly identical outcomes from operative and nonoperative treatments, with 88 and 87% satisfactory outcomes, respectively. However, the need for additional surgery (59% versus 6%) and infection (6% versus 1%) was notably higher in patients who had surgery. Also, there was not found to be any decrease in the time to return to normal activities or decreased chronic discomfort or pain with surgery.

While the majority of Type III injuries should be managed nonoperatively, absolute indications for operative treatment include open injuries, significant brachioplexus injury, and injuries that remain chronically symptomatic. Relative indications for surgical stabilization include greater than 2 cm displacement, significantly prominent clavicle in manual laborers, or a highlevel overhead or throwing athlete.<sup>15,16,20-23</sup>

Our approach to Type III injuries is for an initial trial of nonoperative treatment in all patients and to reserve surgical stabilization for chronically symptomatic injuries.

## SURGICAL OPTIONS

While over 60 surgical procedures have been described for the treatment of acromioclavicular joint instability, there are essentially two treatment options. The surgical options for acute and chronic acromioclavicular joint instability include either (1) coracoclavicular ligament reconstruction with or without distal clavicle excision or (2) coracoclavicular stabilization with repair or reconstruction of the coracoclavicular ligaments. Other surgical treatments, including acromioclavicular joint transfixation (with Kirschner wires, Steinman pins, hook plate, or screws) and dynamic muscle transfers, have fallen out of favor due to their technical difficulty and high complication rates.<sup>24-29</sup>

The most popular coracoclavicular ligament reconstruction technique is the Weaver-Dunn reconstruction originally described by Weaver and Dunn in 1972.<sup>30</sup> There have been several modifications since then. Their original report described excision of the distal clavicle with a coracoacromial (CA) ligament transfer. Modifications, including harvest of the coracoacromial ligament with an acromial bone block and augmentation with autograft tissue, such as the palmaris longus or semitendinosus, and with synthetic suture loops, have been described. Recently, Wolf and Pennington described an all arthroscopic technique.<sup>31</sup> Whatever variant of the Weaver-Dunn reconstruction is chosen, the transfer of the coracoclavicular ligament can be used for both acute and chronic acromioclavicular joint instability.

The second frequently used surgical treatment option is coracoclavicular stabilization with repair or reconstruction of the coracoclavicular ligaments. This technique, originally described using the Bosworth screw, has been popularized by Dr. Rockwood. This is mainly recommended for acute injuries. It can be utilized to assist stabilization in chronic injuries but should not be used alone.

## TECHNIQUE OF AC JOINT RECONSTRUCTION

Our preferred technique of AC joint reconstruction is a Weaver-Dunn variant (Fig 2). When possible, this is performed under regional anesthesia with the patient in a beach chair position. The incision is centered in line with Langer's lines approximately 1.5 cm medial to the AC joint and should be slightly angled to allow access laterally to the CA ligament and medially to the coracoid process. Beginning at the posterior aspect of the distal clavicle, the incision extends anteriorly to the coracoid process. Subcutaneous skin flaps are elevated to allow placement of a self-retaining retractor. The underlining deltoid fascia is carefully identified and the deltoid can be either elevated as a flap or lifted off in its entirety. We prefer to take the deltoid down with a "hockey stick" incision to visualize the coracoid process. The length of the deltoid elevation incision is made over the mid portion of the clavicle with electrocautery and extends laterally beyond the meniscal homologue to the edge of the acromion. Typically, the injury to the AC joint is readily apparent. The acromioclavicular ligaments are split from medial to lateral and are preserved to repair following the reconstruction. Once a periosteum flap has been elevated with electrocautery and elevators, a tagging suture is placed in the medial-most aspect of the periosteum flap. Just medial to the tagging stitch, the incision is carried inferiorly to complete the "hockey stick" elevation of the deltoid and allow visualization of the coracoid. The tagging suture allows accurate reattachment of the deltoid on closure.

Once the deltoid has been lifted off the clavicle, the plane just superficial to the CA ligament should be identified and excess soft tissue removed to define the borders of the ligament. To fully visualize the coracoacromial ligament, dissection must be performed laterally. As attention is turned to harvesting the coracoacromial ligament it is important to understand that the ligament has a wide insertion that extends posterior from the undersurface of the acromion. If care is taken during harvesting of the coracoacromial ligament, important additional length routinely can be obtained. The CA ligament is secured with two heavy, nonabsorbable sutures, one placed at each side of the harvested ligament using a whipstitch. To determine the location for the clavicle resection, the CA ligament is directed superiorly to determine the most direct and therefore shortest route to the clavicle. This location will serve as the location for the distal clavicle resection. Typically this results in 10 to 20 mm of the distal clavicle being resected with an oscillating saw. We angle the clavicle cut to leave slightly more superior clavicle to make the turn into the medullary canal of the clavicle less abrupt for the harvested CA ligament. With a small curette the medullary canal is opened to allow passage of the harvested ligament. Laterally the intraarticular disc is resected, with care taken to preserve the AC ligaments. Before transfer of the CA ligament, anterior and posterior drill holes are made in a cruciate fashion (ie, enter the lateral clavicle anteriorly and exit the medial clavicle posteriorly and visa versa) in the clavicle, with a 2.0-mm drill bit exiting approximately 15 to 20 mm medial to the clavicle cut. Each hole will be used to pass one suture limb of the

harvested CA ligament. Having a shorter span for the suture to exit medially from the clavicle may prevent adequate tensioning as the suture-tendon edge may engage the inner clavicle cortex before the clavicle is fully reduced. To assist in the passing of the heavy, nonabsorbable suture we use a wire loop (Linvatec, Largo, FL).

Before reducing the clavicle and tying the suture limbs over the superior cortex of the clavicle, the repair can be augmented. Additional fixation can be achieved with either autogenous tissue, such as a palmaris longus or semitendinosus graft, or with various types of synthetic sutures loops. In overhead athletes or in revision cases we routinely augment the CA ligament transfer with an autogenous tendon graft. Otherwise, we routinely secure the repair with nine No. 1 absorbable sutures. The sutures are wrapped in the fashion of a high-tension cable cord.<sup>32</sup> Three sutures are placed together and clamped at each end. While holding one end of the suture, the free end is rotated clockwise approximately 30 times. This is repeated for two other sets of three sutures, creating three sets of three sutures. The three suture sets are then placed together and wrapped counterclockwise approximately 30 times. This creates a uniform cable of sutures that is easily manageable. With a curved wire loop (Linvatec), a heavy suture is passed around the coracoid base which is used to shuttle the suture cable around the coracoid. Rather than passing the cord of sutures around the entire clavicle, which would anteriorly displace the clavicle when secured to the coracoid, the cord is passed through a superior to inferior directed 3.5-mm drill hole in the clavicle just medial to the smaller exiting drill holes. Next, the clavicle is reduced and the suture limbs of the transferred CA ligament are tied over a large bony bridge on the superior clavicle cortex. Since the displacing forces are significant and occasionally there is some graft lengthening over time, it is not uncommon for the reduction obtained during surgery to be lost with time. While this is infrequently painful, we recommend slight overreduction the CA ligament graft to reduce the frequency of this outcome and its unsightly deformity. Again, the canal of the clavicle may have to be revisited with curettes to make a large enough opening to allow passage of the CA ligament within the clavicle. After securing the reconstruction reduction, the cable of large absorbable sutures is tied. Care is taken to keep the knot sutures from being too prominent on the anterior surface. Also, following tying of the cable, its ends are unraveled and individual sutures are tied to prevent unraveling of the cable.

The AC ligaments and trapezial fascia are then meticulously closed with heavy nonabsorbable No. 2 suture. We prefer to use buried sutures to prevent any irritation from the knots. Following wound closure, the patient is placed into a sling with a waist support (DonJoy, Vista, CA). The sling helps to elevate the proximal humerus and acromion and prevent additional stress on the reconstructed ligaments.

The patient is immobilized for 6 weeks and then begins active and active assisted motion. Strengthening is typically delayed until 12 weeks after surgery. Return to contact sports is avoided for approximately 5 to 6 months.

## RESULTS

Reflecting the multiple variations of acromioclavicular joint stabilization techniques, there is not a clearly superior technique. Outside of comparing acromioclavicular joint fixation techniques to coracoclavicular fixation techniques, few studies have compared different surgical techniques.<sup>33</sup> However, a few principles have emerged. Coracoclavicular fixation is generally favored over acromioclavicular joint fixation because of its superior results, lower complication rates, and decreased late acromioclavicular joint arthrosis.<sup>25,34</sup> Regarding coracoclavicular ligament reconstruction techniques, removing the distal clavicle at the time of coracoclavicular ligament reconstruction is generally favored because of higher rates of acromioclavicular joint arthrosis with distal clavicle preservation.<sup>34</sup>

## COMPLICATIONS

Complications can be divided into three groups—pre-, intra-, and postoperative.

Preoperative complications include skin compromise from delayed surgery with Type V injuries and unrecognized additional injuries, such as clavicle, acromion, and coracoid fractures and pulmonary issues.<sup>35-37</sup> Intraoperative complications are technique related. They include inadequate CA ligament length, excessive distal clavicle excision, fracture of the coracoid, and neurovascular injuries, such as axillary artery and vein along with musculocutaneous nerve and brachial plexus injuries. Postoperative complications are numerous. Persistent deformity or loss of reduction is frequent, over 40% in one study.<sup>38</sup> Fortunately, the majority of these complications are not symptomatic. Infection is especially a concern from the lack of soft tissue coverage and the presence of prominent hardware or sutures. In one study with screw fixation, there was a 15% infection rate.<sup>15</sup> Use of nonabsorbable suture is also a concern for infection as it may serve as a possible nidus for infection.<sup>39</sup> Another source of postoperative complications is hardware related. There have been reports of Kirschner wires and Steinman pin migration<sup>26,40-42</sup> along with erosion and fracture of the clavicle from wire or nonabsorbable suture.<sup>26,40-45</sup> Last, failure to resect the distal clavicle may result in AC joint arthrosis.<sup>34</sup>

## SUMMARY

While injuries to the AC joint are common, instability leading to chronic pain is less frequent. Type I and II injuries are nonoperatively treated. Type IV–VI injuries are surgically treated. Regarding Type III AC separations, we feel that nearly all cases merit a trail of nonoperative treatment before embarking on surgical reconstruction to restore stability and function and relieve pain. Our preferred technique to stabilize the AC joint is a modified Weaver-Dunn with augmentation using nine large absorbable sutures wrapped in a tension cable cord fashion. The tension cable cord wrap is easily reproduced and provides a strong cord that is easy to work with. One critical technical point that we feel is frequently overlooked is being able to transfer a sufficient portion of the CA ligament within the clavicle to allow proper tensioning of the clav-

icle before securing the augmentation fixation. Use of this and similar repairs reproducibly restores function and relieves pain from instability of the acromioclavicular joint.

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