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Detailed management of post-traumatic distal clavicle osteolysis in a 24-year-old female: a case report

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Introduction: *Distal clavicular osteolysis (DCO) is a musculoskeletal pathology characterized by shoulder pain. Given the high prevalence of shoulder pain due to rotator cuff and subacromial injuries, DCO is often overlooked. Conservative therapy is indicated prior to surgical intervention. However, no literature has described conservative management of DCO in detail. This report will outline conservative management details for DCO to guide future research and clinicians.*

Case presentation: *A 24-year-old female hockey player presented with trauma-induced injury, where she was diagnosed with type II acromio-clavicular joint separation. She presented 5-months later with residual pain and limitations in ranges of motion (ROM). Radiographic images revealed DCO.*

Prise en charge détaillée d'une ostéolyse post-traumatique de l'extrémité externe de la clavicule chez une femme de 24 ans : compte rendu de cas

Introduction : *L'ostéolyse de l'extrémité externe de clavicule (OEEC) est une pathologie musculosquelettique caractérisée par des douleurs d'épaule. La fréquence des douleurs d'épaule dues à des lésions de la coiffe des rotateurs et des lésions sous-acromiales est élevée, mais l'OEEC est souvent inaperçue. Un traitement conservateur est indiqué avant l'intervention chirurgicale. Comme aucune littérature ne décrit en détail le traitement conservateur de cette pathologie, nous présentons un compte rendu détaillé de ce traitement pour guider les recherches futures et les cliniciens.*

Présentation du cas : *Une joueuse de hockey de 24 ans s'est présentée avec une blessure traumatique à l'épaule. On a diagnostiqué une disjonction acromio-claviculaire de type II. Elle s'est présentée 5 mois plus tard avec des douleurs résiduelles et des limitations de l'amplitude des mouvements. Les radiographies ont révélé une OEEC.*

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Management and outcome: *Management entailed strict rest from overhead activities followed by rehabilitation and manual therapy. 6-months later the patient reported resolution of symptoms, improved ROMs, and activities of daily living.*

Summary: *DCO can be difficult to diagnose given its limited etiological understanding, low incidence, and poor radiographic sensitivity. DCO diagnosis should be considered in cases with unresolving shoulder pain.*

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KEY WORDS: post traumatic distal clavicle osteolysis, acromio-clavicular separation, chiropractic, rehabilitation, shoulder pain

Prise en charge et résultats : *La prise en charge a consisté en un arrêt complet des activités au-dessus de la tête, suivi d'une rééducation et d'une thérapie manuelle. Six mois plus tard, la patiente n'avait plus de symptômes, avait repris ses activités quotidiennes et l'amplitude de ses mouvements s'était améliorée.*

Résumé : L'*OEEC peut être difficile à diagnostiquer parce que nos connaissances sur son étiologie sont limitées, que sa fréquence peu élevée et que cette pathologie est difficile à visualiser sur les radiographies. Le diagnostic d'une OEEC doit être envisagé dans les cas de douleurs d'épaule qui ne disparaissent pas.*

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MOTS CLÉS : ostéolyse post-traumatique de l'extrémité externe de la clavicule, disjonction acromio-claviculaire, chiropratique, rééducation, douleur à l'épaule

Introduction

Distal clavicular osteolysis (DCO) is a musculoskeletal (MSK) pathology characterized by shoulder pain in adults. There are two types of DCO: atraumatic DCO, caused by repetitive stress and first described in 1959 by Ehricht and colleagues[1], and traumatic DCO, caused by a traumatic injury and first described in 1961 by Kohler in Swiss and German Literature. Atraumatic DCO has been associated with lifting weights and at high intensities[2], whereas traumatic DCO may follow acromioclavicular (AC) joint separation[3].

Although the etiological and exact pathogenesis of DCO is unclear, it has been previously reported by Cahill and colleagues that microfractures of the subchondral bone exist with signs of repair in the distal clavicle of surgical specimens[4]. Although Brunet *et al*.[5] later suggests a pathophysiological process of synovial invasion of the subchondral bone leading to osteolysis, Cahill's hypothesis remains more widely accepted.

Limited epidemiological data exists for DCO. A study by Yu *et al*. [6] reported a 6-12% incidence rate of developing osteolysis of the distal clavicle following AC joint separations. However, the population prevalence of traumatic DCO remains unknown. As for atraumatic DCO, Nevalainen *et al*.[2] found a 5% prevalence in an adult population with shoulder pain and further noted a high correlation with high-intensity bench pressing.

Given the high prevalence of shoulder pain due to rotator cuff and subacromial injuries, DCO is often overlooked. Making matter worse, it is also sometimes misdiagnosed as AC joint separation sequalae, especially following an acute injury. On presentation, DCO patients complain of vague anterior shoulder pain that may radiate to the trapezius or deltoid region. Reported aggravating factors include weight training (e.g., bench presses, push-ups), overhead activities and horizontal adduction. On examination, the pain is reproduced with palpation of the affected AC joint and with a cross-body adduction maneuver.[7]

Following history and physical examination, if clinical suspicion for DCO is present, then radiographic workup of the AC joint should be considered. Imaging may reveal loss of subchondral bone in the distal clavicle, cystic changes in the subchondral bone, as well as widening of the AC joint. As all these findings are often subtle and difficult to detect, the images must be meticulously examined. However, a meticulously examined negative study is still not sufficient to confidently rule out DCO. In a

study by Yu and colleagues[6], x-rays detected DCO findings only 50% of the time; MRIs were more sensitive. MRI findings include cortical irregularity, periarticular erosions, joint widening, soft tissue swelling, and edema.[6]

As for treatment, conservative management is the primary goal prior to surgical considerations.[8,9] Despite this, however, only few studies have outlined non-surgical treatment options for DCO. DeFroda *et al*.[8] recommends nonsteroidal anti-inflammatory drugs (NSAIDS), steroid injections, activity modification, avoidance of provocative exercises, and physical therapy. The reference reporting physical therapy suggests mobilization techniques similar to those utilized in treating AC joint osteoarthritis.[10] There was no pragmatic description of rehabilitative interventions specific to DCO. Another study by Mestran *et al*.[11] examines seven case studies of traumatic and atraumatic DCO patients – all seven patients underwent conservative therapy, with strongly improved clinical outcomes in four out of the seven cases. The authors described varied treatment methods including sling immobilization, ice, and mobilization exercises. Again, however, there was no descriptive mention of the specific mobilization exercises used.

Thus, despite recommendation for conservative management prior to seeking surgical intervention, the literature lacks in providing clinicians with full descriptions of the conservative care treatment options. This report aims to describe detailed conservative management options, effectively highlighted through a successful case, to help guide clinicians and future researchers with DCO management.

Case presentation

A 24-year-old female presented to the clinic with an acute onset of left shoulder pain after a hockey injury the night before. The patient described a mechanism of injury where her opponent had collided with her left shoulder from the back as she was attempting to shoot. After the collision, the patient fell onto the ice on the same shoulder. The patient recalls immediate sharp, 10/10 pain that prevented her from moving her shoulder in any direction. Aggravating factors at the time included any movements involving the left arm, while relieving factors included ice-application and rest. Physical examination revealed a minor step-defect and minimal soft tissue swelling surrounding the AC joint region. Palpation reproduced pain directly at the AC joint and elicited tenderness over the surrounding shoulder musculature. The left glenohumeral (GH) active ranges of motion (ROM) were minimal with associated pain apprehension, and the horizontal adduction test was positive for pain. The patient was ultimately diagnosed with acute type II AC joint separation.

A week after the incident, the patient started to experience significant decrease in symptoms. She regained the majority of her GH ROM and her pain was present only at the end ranges of flexion, abduction, and horizontal adduction. The symptoms continued to subside over the next month and she was able to participate fully in her work duties, daily living activities, and even her normal gym routine.

Five months later, the patient returned to the clinic with residual shoulder pain. Her pain was now described as noticeably dull-achy, rated 3/10 on the numeric pain rating scale, and was diffusely present throughout the anterior and posterior aspects of her left shoulder. It was aggravated by sleeping on the left side, performing work duties, holding the steering wheel while driving, overhead weight-presses and performing handstands. Relieving factors included rest from all the aforementioned aggravating factors. The patient was otherwise healthy with no past medical problems. Her review of systems was unremarkable and no red flags were raised.

Examination of the left shoulder was positive for pain in active ranges of motion, and limited range to 130° of flexion, 20° of extension, 110° of abduction, 90° of external rotation, and 10° of internal rotation. There was decrease of strength (grade 4/5) in both external and internal rotation. Painful Arc test was positive for pain at 90° and at end-range, and scapular dyskinesia was observed. There was also tenderness upon palpation of the AC joint line, as well as the surrounding shoulder and neck musculature. The QuickDASH functional scale was 27.27. Additional exam findings included joint restrictions at the cervicothoracic junction, chest elevation and accentuated rib flaring on functional assessment of resting inhalation, and an anteriorly rolled shoulder.

Radiographic images taken at this time (five months post injury) noted a subtle radiographic suggestion of osteolysis of the distal clavicle (see Figure 1). The patient was diagnosed with left post-traumatic distal clavicle osteolysis.

Rest from provocative ranges of motion was adopt-

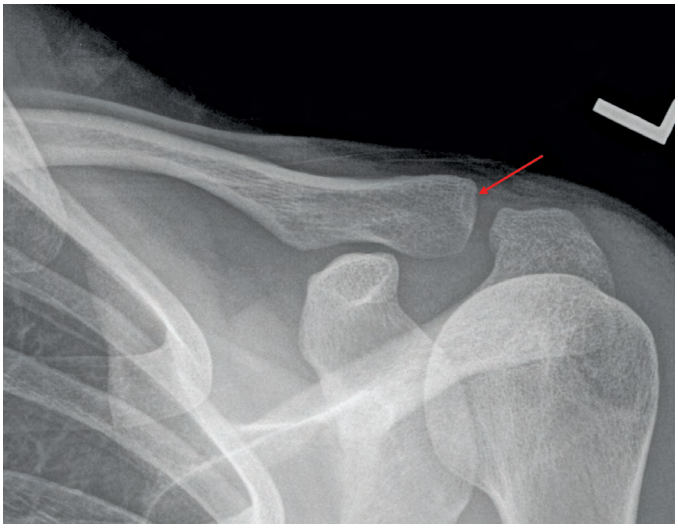


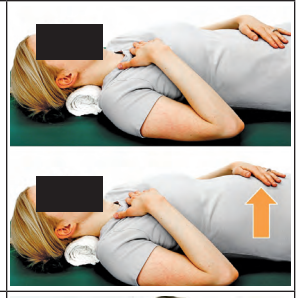
Figure 1.
The arrow points directly at the subtle focal cortical resorption observed in the superior aspect of the left distal clavicular articular margin

ed immediately – again, these ranges were flexion, abduction, internal rotation and horizontal adduction. The patient then underwent a conservative management plan for one to two times per week for ten weeks. This consisted of soft tissue therapy (STT), spinal manipulation therapy (SMT), and rehabilitation exercises. Soft tissue therapy targeted pectoralis minor, teres minor and major, supraspinatus, infraspinatus, subscapularis, rhomboids minor and major, latissimus dorsi, trapezius, and levator scapulae. Spinal manipulative therapy was provided for the cervical and thoracic spine restricted segments. In addition, stretching exercises of the pectoralis minor (where the body rotates away from a fixed arm position against the wall) were also prescribed.

After her symptoms began to improve, rehabilitation exercises were commenced. The following progressive exercises in three-phases (see Tables 1-3) were prescribed. The first phase included exercises below the horizontal plane; the second phase included exercises above the horizontal plane; and the third and last phase included active exercises in a closed kinetic chain (see Tables 1-3 for more details). The overall purpose of the exercises was to improve her scapular kinesis and ultimately GH ROM.

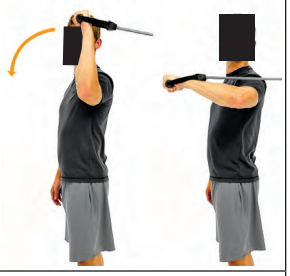
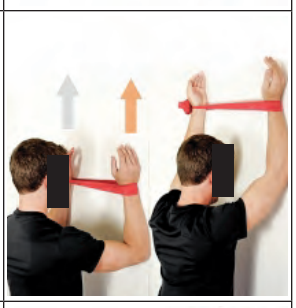
Approximately one year after initial presentation, the

Table 1.
Shoulder rehab below horizontal

Phase 1	**Rehab Exercise**
Concentric and eccentric external and internal rotations of glenohumeral joint using resistive band. Shoulders are 0 degrees flexion. Elbows are at 90 degrees flexion. Sets: 3 Repetitions: 10 Frequency: daily	
Push up-plus against the wall or against a table in incline position. Focusing on scapular control in protraction and retraction Sets: 3 Repetitions: 10 Frequency: daily	
Diaphragmatic breathing in supine position with elevated legs. The focus was to inhale while increasing intra-abdominal pressure, then exhaling while relaxing intra-abdominal pressure. Sets: 3 Repetitions: ~60 seconds Frequency: daily	
Upright-Rows was done with resisted band then eventually with weighted-cables. The elbow is not abducted beyond 90 degrees. Trunk is upright. Sets: 3 Repetitions: 10 Frequency: daily	

patient was re-evaluated and her symptoms were re-assessed. Not only did the patient report complete resolution of symptoms, but prior aggravating factors such as overhead weight-presses, and performing work duties were no longer bothersome or of concern. On examination, follow up Quick DASH score was 4.55; palpation of

Table 2.
Shoulder rehab above horizontal

Phase 2	**Rehab Exercise**
Concentric and eccentric external and internal rotations of glenohumeral joint using resistive band. Shoulders are 90 degrees abduction. Elbows are at 90 degrees flexion. Sets: 3 Repetitions: 10 Frequency: daily	
Push up-plus against horizontal position. Focusing on scapular control in protraction and retraction Sets: 3 Repetitions: 10 Frequency: daily	
Scapular-clocks were performed against the wall. A resistance band was wrapped around both arms. While one arm is stabilized, the other moved downwards, sideways, and upwards against the wall in a controlled fashion without shoulder-hiking. Sets: 3/arm Repetitions: 10/arm Frequency: daily	
Diaphragmatic breathing in supine position with elevated legs was progressed to a Deadbugs exercise. The focus was to allow arm flexion without shoulder-hiking while maintaining diaphragmatic breathing. A yoga ball can be used for guidance. Sets: 3 Repetitions: 10X/side Frequency: daily	
Bent-over rows was done with weights. The emphasis was to focus on scapular retraction without shoulder hiking while maintain spinal neutral position. Sets: 3 Repetitions: 10 Frequency: daily	

the AC joint was no longer painful; and active GH ROM was now full and pain free. The only positive exam finding was residual decrease in strength (grade 4/5) with internal rotation.

Discussion

DCO can be difficult to diagnose given the poorly understood pathology and limited etiological understanding, the low incidence rate, and the lack of radiographic sensitivity. It can be very easily missed, especially following acute trauma. However, identifying this uncommon pathology in patients is crucial in order to execute the appropriate plan of care. Unlike most MSK conditions, initial exercise is ought to be contraindicated in DCO patients. As previously mentioned, Cahill and colleagues in 1982 identified microfractures of the subchondral bone in surgical specimens of DCO patients. Because regular bone fractures are usually treated with casting, splinting, or immobilization as the primary management, the authors suggest that microfractures present in DCO should be

Table 3.
Shoulder rehab in closed kinetic-chain

Phase 3	**Rehab Exercise**
Scapular Hangs were performed from passive hanging position where the trunk is in depressed position relative to the scapula, to an engaged position where the trunk is in elevated relative to the scapula. Sets: 1-2 Repetitions: 10 Frequency: daily	
Low oblique sit according to dynamic neuromuscular stabilization. Isometrically depressing the scapula relative to the trunk. The trunk is elevated off the ground to neutral position relative to the shoulder complex. Ensuring diaphragmatic breathing in this isometric position without fatiguing into shoulder-hiking and depressed trunk. Sets: 3 Repetitions: 30 seconds/side Frequency: daily	

also be treated similarly, with a period of rest before initializing rehabilitation, allowing for physiological bone healing. Therefore, patients should be educated on avoiding painful ROM, to avoid reinjuring the joint pathology. It is in the opinion of the authors that patient education regarding bone healing and limiting provocative ranges of motion is of high priority to improve compliance and prognosis.

In our case, once a sufficient amount of time was given to allow for healing and pain relief, active rehabilitation was commenced with the intention to regain neuromuscular control of the shoulder complex. This is especially important after a period of prolonged rest. Scapular control and its relationship to glenohumeral rhythm was emphasized to reinstate optimum shoulder mechanics.[12] Emerging evidence investigating the association between scapular dynamic stability with shoulder pathologies reported different examples of altered scapular kinematics including: reduced clavicle retraction, scapular upward rotation, scapular posterior tilt and increased clavicle elevation. As such, enhancing optimal clavicle kinematics via scapular dynamic stability exercises is thought to alleviate excessive pressure on the AC joint.[13] This rehabilitation approach was particularly relevant given that our patient demonstrated scapular dyskinesia on repeat examination.

Further addressing functional deficits, our patient demonstrated chest rising with rested inhalation. As this may indicate excessive utilization of the pectoralis minor, deep neck flexors, sternocleidomastoid, and other secondary respiratory musculature, diaphragmatic breathing and deadbugs were prescribed to address this functional deficit. It is thought that diaphragmatic breathing further strengthens core musculature by increasing intra-abdominal pressure (IAP) which stabilizes the spine by activation of the diaphragm, pelvic floor, and transversus abdominis. This provides a fixed stable base from which extremity musculature can generate movement, including the shoulder complex.[14] Ensuring a fixed stable base of support allows for optimal load transference across the joint without mechanical stress on the passive structures such as ligaments, joint surfaces, cartilage, and osseous structures.

Active scapular hangs were included to improve grip strength, as it has been shown to improve shoulder internal and external rotational torque.[15] Altered scapular kinematics may not only be attributed to muscular recruitment patterns[16,17], but also lack of flexibility and tissue compliance in the scapular peri-articular musculature. Lack of flexibility may restrict normal scapular movement.[18] Therefore, passive care of STT and SMT of the cervical and thoracic spine, was provided for relief of tenderness and improving GH ROM.[19]

It is noteworthy to indicate that there is no consensus regarding the cause-consequence relationship between shoulder/neck pain and scapular dyskinesis. It is likely there are several mechanisms that can contribute to shoulder pathology such as DCO, including post-traumatic stress, repetitive altered shoulder kinematics, scapular dyskinesia, thoracic posture and/or soft tissue stiffness. Irrespective of the direction of cause and effect, altered neck or shoulder mechanics may jeopardise optimal shoulder function and consequently decrease width of the AC joint, continuing to insult the DCO pathology. Improving cervical and thoracic ranges of motion was considered necessary to the shoulder biomechanics from a regional interdependence perspective.[20] Stretching was instructed specifically for the pectoralis minor to prevent excessive GH protraction given that our patient demonstrated anteriorly rolled shoulder on the symptomatic side, with the intention to prevent excessive AC joint loading.

Of note, the patient's step-defect did not resolve. However, this is a direct result of the traumatic incident leading to the type II AC joint separation and will not resolve with conservative care.

This case report is not without limitations. Radiographic images were obtained but follow up imaging was not performed to fully explore the long-term changes radiographically. MRI is more sensitive to visualize DCO findings[6] but was not deemed necessary to guide the patient management for this case and is not routinely used due to its high costs and limited availability. Given the decreased sensitivity associated with X-ray findings for DCO[6], one must consider differential diagnoses associated with the persistent symptoms such as: chronic AC joint sprain, AC joint instability, as well as osteoarthritis of the AC joint. The differential diagnosis of chronic AC joint sprain (failure of initial rehab is plausible), it would not explain the cystic findings visualized on X-ray. The second differential of joint instability is also a plausible diagnosis, but this is unlikely since our radiographs found no evidence of vertical instability (grade III injury particularly disrup-

tion of the coracoclavicular (CC) ligaments) and our clinical exam found no signs of malalignment on observation or under loads.[21] It is also plausible to consider horizontal joint instability due to disruption of the AC ligaments but there is a lack of consensus available regarding evaluation and diagnosis.[22] A third differential of osteoarthritis of the AC joint is also plausible but given the short timeline; in this case of five months and young age of the patient; it is unlikely arthritic in nature.

The positive outcome in this case confirms the suggestion from previous literature that conservative management should be attempted prior to pursing surgical options. Unfortunately, there is a literary gap in descriptions of detailed and specific conservative management interventions and protocols from a manual therapy and active rehabilitation standpoint. This case report is to provide guidance for clinicians on a non-surgical approach for patients with DCO. The graduated and multi-modal conservative approach presented is an integral component for successful treatment of DCO.

Clinical applicability

1. Consider a diagnosis of DCO especially with a previous history of a traumatic event to the shoulder or unresolving superior shoulder pain with concurrent history of repetitive overhead shoulder use.
2. Consider radiographic images after prolonged shoulder pain as further investigative workup. However, be aware that DCO cannot reliably be ruled out on radiographs alone and MRI may be necessary to elicit the bony changes.
3. Once diagnosis is confirmed, halt aggravating maneuvers until symptoms completely subside.
4. Consider manual therapy and a sequential rehabilitation protocol to restore shoulder function.

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References

1. Ehricht HG. Die Osteolyse im lateralen Claviculaende nach Preßluftschaden. Arch Orthop Unfallchir. 1959;50(6):576-582. doi:10.1007/BF00416343
2. Nevalainen MT, Ciccotti MG, Morrison WB, Zoga AC, Roedl JB. Distal clavicular osteolysis in adults: association with bench pressing intensity. Skeletal Radiol. 2016;45(11):1473-1479. doi:10.1007/s00256-016-2446-z
3. Asano H, Mimori K, Shinomiya K. A case of post-traumatic osteolysis of the distal clavicle: histologic lesion of the acromion. J Shoulder Elb Surg. 2002;11(2):182-187. doi:10.1067/mse.2002.122229
4. Cahill BR. Osteolysis of the distal part of the clavicle in male athletes. J Bone Jt Surg – Ser A. 1982;64(7):1053-1058. doi:10.2106/00004623-198264070-00015
5. Brunet ME, Reynolds MC, Cook SD, Brown TW. Atraumatic osteolysis of the distal clavicle: histologic evidence of synovial pathogenesis. A case report. Orthopedics. 1986;9(4):557-559. doi:10.3928/0147-7447-19860401-15
6. Yu JS, Dardani M, Fischer RA. MR observations of posttraumatic osteolysis of the distal clavicle after traumatic separation of the acromioclavicular joint. J Comput Assist Tomogr. 2000;24(1):159-164. doi:10.1097/00004728-200001000-00028
7. Nuber GW, Bowen MK. Arthroscopic treatment of acromioclavicular joint injuries and results. Clin Sports Med. 2003;22(2):301-317. doi:10.1016/S0278-5919(03)00014-0
8. DeFroda SF, Nacccca C, Waryasz GR, Owens BD. Diagnosis and management of distal clavicle osteolysis. Orthopedics. 2017;40(2):119-124. doi:10.3928/01477447-20161128-03
9. Schwarzkopf R, Ishak C, Elman M, Gelber J, Strauss DN, Jazrawi LM. Distal clavicular osteolysis: a review of the literature. Bull NYU Hosp Jt Dis. 2008;66(2):94-101. Accessed August 19, 2020. https://pubmed.ncbi.nlm.nih.gov/18537776/
10. Cibulka MT, Hunter HC. Acromioclavicular joint arthritis treated by mobilizing the glenohumeral joint. A case report. Phys Ther. 1985;65(10):1514-1516. doi:10.1093/ptj/65.10.1514
11. Mestan MA, Bassano JM. Posttraumatic osteolysis of the distal clavicle: analysis of 7 cases and a review of the literature. J Manipulative Physiol Ther. 2001;24(5):356-361. doi:10.1067/mmt.2001.115260
12. Panagiotopoulos AC, Crowther IM. Scapular dyskinesia, the forgotten culprit of shoulder pain and how to rehabilitate. SICOT-J. 2019;5:29. doi:10.1051/sicotj/2019029
13. Cools AMJ, Struyf F, De Mey K, Maenhout A, Castelein B, Cagnie B. Rehabilitation of scapular dyskinesis: from the office worker to the elite overhead athlete. Br J Sports Med. 2014;48(8):692-697. doi:10.1136/bjsports-2013-092148
14. Davarian S, Maroufi N, Ebrahimi E, Parnianpour M, Farahmand F. Normal postural responses preceding shoulder flexion: co-activation or asymmetric activation of transverse abdominis? J Back Musculoskelet Rehabil. 2014;27(4):545-551. doi:10.3233/BMR-140480

15. Lee DR, Kim LJS. Effects of hand grip exercise on shoulder joint internal rotation and external rotation peak torque. J Back Musculoskelet Rehabil. 2016;29(3):521-525. doi:10.3233/BMR-150652
16. Cools AM, Witvrouw EE, Declercq GA, Vanderstraeten GG, Cambier DC. Evaluation of isokinetic force production and associated muscle activity in the scapular rotators during a protraction-retraction movement in overhead athletes with impingement symptoms. Br J Sports Med. 2004;38(1):64-68. doi:10.1136/bjsm.2003.004952
17. Cools AM, Declercq GA, Cambier DC, Mahieu NN, Witvrouw EE. Trapezius activity and intramuscular balance during isokinetic exercise in overhead athletes with impingement symptoms. Scand J Med Sci Sport. 2007;17(1):25-33. doi:10.1111/j.1600-0838.2006.00570.x
18. Borstad JD, Ludewig PM. The effect of long versus short pectoralis minor resting length on scapular kinematics in healthy individuals. J Orthop Sports Phys Ther. 2005;35(4):227-238. doi:10.2519/jospt.2005.35.4.227
19. Brantingham JW, Cassa TK, Bonnefin D, et al. Manipulative therapy for shoulder pain and disorders: expansion of a systematic review. J Manipulative Physiol Ther. 2011;34(5):314-346. doi:10.1016/j.jmpt.2011.04.002
20. Wainner RS, Whitman JM, Cleland JA, Flynn TW. Regional interdependence: a musculoskeletal examination model whose time has come. J Orthop Sports Phys Ther. 2007;37(11):658-660. doi:10.2519/jospt.2007.0110
21. Cisneros LN, Reiriz JS. Management of chronic unstable acromioclavicular joint injuries. J Orthop Traumatol. 2017;18(4):305-318. doi:10.1007/s10195-017-0452-0
22. Aliberti GM, Kraeutler MJ, Trojan JD, Mulcahey MK. Horizontal instability of the acromioclavicular joint: a systematic review. Am J Sports Med. 2020;48(2):504-510. doi:10.1177/0363546519831013