Surgical Management of Type III Acromioclavicular Joint Dislocation – The Biomechanical basis for Reconstruction

Cary Fletcher

Saint Ann's Bay Regional Hospital

Abstract- The acromioclavicular joint (ACJ) is a diarthrodial joint which is stabilized by static and dynamic stabilizers. Acromioclavicular (AC) ligaments and the coracoclavicular (CC) ligaments (trapezoid and conoid) and the coracoacromial ligament make up the static stabilizers. The dynamic stabilizers are the deltoid and trapezius muscles. The principles of various surgical techniques involve reduction of the AC joint and were historically classified into two groups: those that focus on primary healing of the CC ligaments and those meant to reconstruct the CC ligaments. Ligament reconstruction must have sufficient immediate stability to prevent acute redisplacement or be protected temporarily until the region heals. The biomechanical basis for reconstructing the CC ligaments in the management of acromioclavicular type 3 injuries is discussed.

Keywords: acromioclavicular, dislocation, type III.

GJMR-H Classification: NLMC Code: WE 168

SURGICALMANAGEMENTOFTYPEIIIACROMIOCLAVICULARJOINTDISLOCATIONTHEBIOMECHANICALBASISFORRECONSTRUCTION

Strictly as per the compliance and regulations of:

Surgical Management of Type III Acromioclavicular Joint Dislocation – The Biomechanical basis for Reconstruction

Cary Fletcher

Abstract- The acromioclavicular joint (ACJ) is a diarthrodial joint which is stabilized by static and dynamic stabilizers. Acromioclavicular (AC) ligaments and the coracoclavicular (CC) ligaments (trapezoid and conoid) and the coracoacromial ligament make up the static stabilizers. The dynamic stabilizers are the deltoid and trapezius muscles. The principles of various surgical techniques involve reduction of the AC joint and were historically classified into two groups: those that focus on primary healing of the CC ligaments and those meant to reconstruct the CC ligaments. Ligament reconstruction must have sufficient immediate stability to prevent acute redisplacement or be protected temporarily until the region heals. The biomechanical basis for reconstructing the CC ligaments in the management of acromioclavicular type 3 injuries is discussed.

Keywords: acromioclavicular, dislocation, type III.

I. Introduction

The acromioclavicular joint (ACJ) is a robust articulation between the clavicle and the scapula. This articulation serves as a pivot point, as opposed to the sternoclavicular joint which acts as a strut. Due to the design and anatomy of the joint, it can resist a significant amount of the force prior to disruption. Numerous protocols have been devised to treat these injuries and as such, an understanding of the anatomy and biomechanics of the ACJ is important in order to choose the appropriate option for treatment [1]. The following case is presented in order to discuss the biomechanical basis for reconstruction of the coracoclavicular (CC) ligaments for type III ACJ dislocations in patients with an appropriate surgical indication.

II. Case Report

A 60 year old male was riding a bicycle on an asphalted road when the front wheel got trapped in a fissure on the road. He was thrown forwards and landed directly unto his left shoulder. He experienced immediate pain, swelling, and deformity of his left shoulder. Medical attention was sought the same day. He was diagnosed as having a Type III left ACJ dislocation and managed conservatively. He was unhappy with the appearance of the shoulder and complained of an inability to perform overhead activities

Author: Orthopaedic surgeon, Saint Ann's Bay Regional Hospital, Saint Ann. e-mail: c.fletch30@yahoo.com

on the job. His occupation at the time of injury was a construction worker. After five weeks of conservative management, he was referred for operative management.

On examination of the left shoulder, there was an obvious deformity, no tenderness, no distal neurovascular deficits or pain during range of motion (ROM) (see figure 1).

Fig. 1

The ROM was decreased in all directions secondary to weakness. He had grade 4 power in all directions. Radiographs confirmed a Type III ACJ dislocation (see figure 2).


Fig. 2

He was taken to the operating theatre seven weeks post injury. A bra strap incision was made and the ACJ was exposed followed by the coracoid process.

The meniscus was excised. Semitendinosus graft was harvested from the ipsilateral lower limb (see figure 3).

Fig. 3

Two drill holes were placed in the clavicle directly superior to the coracoid process. The semitendinosus autograft was wrapped around the coracoid process and passed through the drill holes in a figure eight configuration post reduction. The graft was sutured onto itself and reinforced with 1.0 vicryl suture which acted as a biological fixation (see figure 4).
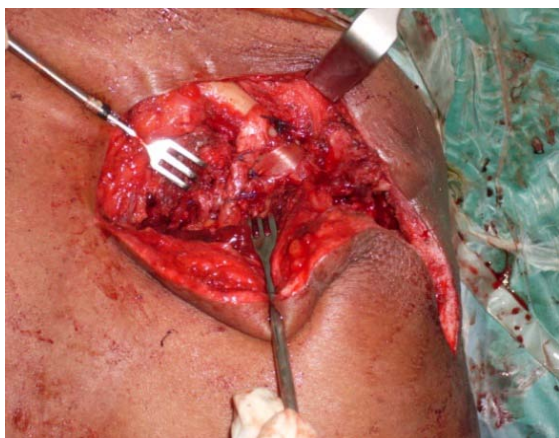
Fig. 4

Postoperatively he was placed in a broad arm sling for six weeks. Pendulum exercises were commenced at two weeks followed by light activities of daily living at four weeks. At eight weeks, active ROM exercises were commenced. He had no pain, and no difficulty performing overhead activities or performing activities of daily living when he was evaluated 18 months after surgery. Ironically, his radiographs revealed a partially reduced ACJ at that time. (See figure 5).

Fig. 5

III. Discussion

The ACJ is a diarthrodial joint, formed by the medial aspect of the acromion and the lateral end of the clavicle. The joint is surrounded by a capsule with synovium and an articular surface made up of hyaline cartilage containing an intra-articular meniscus type structure [1, 2].

ACJ injuries account for approximately nine percent of all shoulder injuries. About 43.5% of the cases occurs in adults in their twenties and are five times more common in males [1]. The incidence is approximately three to four per 100,000 [3].

Transmissions of forces from the appendicular skeleton to the axial skeleton as well as suspending the upper extremity are the primary functions of the ACJ [2]. The ACJ is stabilized by static and dynamic stabilizers. The superior, inferior, anterior and posterior acromioclavicular (AC) ligaments, the CC ligaments (trapezoid and conoid) and the coracoacromial ligament make up the static stabilizers. The dynamic stabilizers are the deltoid and trapezius muscles [1]. The AC ligaments form a strong complex which reinforces the capsule [2]. Serial sectioning of the ACJ ligaments demonstrates that the superior ligament contributes 56% and the posterior ligament contributes 25% of the resistance to posterior displacement of the clavicle [1]. The inferior AC ligament is the major restraint to anterior translation [4]. The CC ligaments perform two major functions. Their attachments between the clavicle and the scapula allow these ligaments to guide synchronous scapulohumeral motion. The other major function is to strengthen the AC articulation [1].

AC joint injuries were classified into three types by Tossy et al [5]. This was later expanded by Rockwood [6] in 1984, to include type IV to VI. Type I is an AC ligament sprain with an intact joint. In type II, AC ligaments are torn but CC ligaments are intact. Type III which the index case suffered, represents torn AC and CC ligaments with 100% superior ACJ dislocation. In type IV, there is complete dislocation with posterior displacement of the distal clavicle into or through the trapezius muscle. Type V is an exaggerated superior

dislocation of the AC joint between 100% and 300% in which the deltotrapezial fascia is disrupted. Type VI is a displaced distal clavicle into a subacromial or subcoracoid position [6].

Lee et al [4] suggested that the CC and AC ligaments should be considered for reconstruction to restore normal joint function. The AC ligaments are the primary restraints to posterior and superior translation of the clavicle initially [7]. The conoid ligament is the primary restraint to superior translation (62%), though the AC ligaments remain the primary restraint to posterior displacement [7]. The primary restraint to compression of the AC joint is the trapezoid ligament [7]. Fukuda [7] stated "if maximum strength of healing after an injury to the AC joint is the goal, all ligaments should be allowed to participate in the healing process." That statement was the basis for some authors to perform reconstruction as their primary surgical treatment [1].

The shoulder suspensory complex is composed of the superior glenohumeral ligament, coracoid process, CC ligaments, the distal clavicle, AC joint and the acromion. Damage to part of this complex must also produce disruption of another portion of the osteoligamentous ring. Types III to VI fall in this category of double disruption [8].

Dislocation of the AC joint usually results from direct trauma (such as the index case), but may occur with indirect trauma. The usual mechanism is a force applied to the shoulder with the arm adducted [2]. Chronic symptoms may occur after minor or severe injuries to the AC joint but more commonly in association with higher levels of disruption [9].

The management of Type III AC joint dislocation remains controversial, with a trend towards non-operative management [2, 9, 10, 11, 12, 13, 14]. The natural history of untreated AC joint dislocations Type III suggests that the majority of patients do well without formal treatment; however a small percentage such as the index case, require delayed surgical intervention [11]. The index case had reduced function as evidenced by an inability to perform overhead activities on the job as well as he was unhappy about the shoulder deformity. Bannister [12] noted that patients treated non-operatively had earlier return to work or sports and regained motion faster. Some authors reserve operative management for high level pitchers, open injuries, brachial plexopathy or severe Type III dislocations [2]. Surgery also has a role in patients with failed non-operative management such as the index case [2, 9, 15]. Schlegel et al [11] noted weakness during bench press and questioned this influence on patients who are manual labourers or weight lifters. Guy et al [16] noted that manual labourers often had residual chronic aching and shoulder weakness. Some authors therefore advocate that patients with high functional demands such as the index case should be treated surgically [16].

In contrast to this, Fremerey et al [14] concluded that being a labourer was not a surgical indication because there was no difference in pain and weakness between their surgical and non-surgical groups, but their numbers were small. The patient being a manual worker was one of the considerations taken into account when surgery was offered to him.

The choice of the best operative technique is controversial [17]. The multiplicity of procedures and lack of a generally accepted method of operative treatment suggests the various techniques carry a substantial risk of resubluxation [17]. The aim of treatment is to return the patient to the level of function before injury, with a pain-free, strong and mobile shoulder [9]. This was achieved in our index case despite not achieving a perfect radiological result.

The principles of the various surgical techniques involve accurate reduction of the AC joint [9]. Operative treatments were broadly classified into two groups: those that focus on primary healing of CC ligaments and those meant to reconstruct the CC ligaments [18]. Reconstruction is performed to mimic normal joint restraints and must have sufficient immediate stability to prevent acute redisplacement [9].

Older surgical techniques include the standard Weaver-Dunn, modified Weaver-Dunn, coracoclavicular suture, AC ligament repair, cerclage slings, screw fixation and free graft reconstruction of the coracoclavicular ligament complex with or without distal clavicular resection (1). The hook plate was subsequently developed to avoid using native tissue for reconstruction [19]. Repair is technically difficult in terms of the surgical access and the structural integrity of the repaired ligament alone is questionable [9].

The standard Weaver-Dunn technique which involves transferring the coracoacromial ligament to reconstruct the coracoclavicular ligaments was initially the most popular procedure, however it has been associated with residual symptoms and unacceptable resubluxation rates. This led to the development of research in evaluating this procedure and the development of newer reconstructive techniques (1). Costic et al (4) performed cyclic loading followed by a load to failure protocol of the normal CC ligament complex in cadavers. This was repeated for an anatomic reconstruction in the same specimen, consisting of ST tendon which replicated the direction and orientation of the trapezoid and conoid ligaments. He noted that although the ST anatomic reconstruction demonstrated a significantly inferior stiffness and ultimate load to failure compared with intact CC ligaments, the stiffness characteristics were much better than the standard Weaver-Dunn procedure (4). The role of the coracoacromial ligament includes prevention of superior migration of the humeral head as well as anterior and inferior instability [20]. Transfer of this ligament may take away its native function to perform another function and

Lee et al [18] felt that transfer should not be done indiscriminately. Coracoacromial transfer is said to fail at small loads during cyclical loading [17].

Modified Weaver-Dunn techniques which augmented the coracoacromial transfer was found to be biomechanically superior to the standard Weaver-Dunn in terms of stability and pullout strength, but none of the techniques restored the AC joint back to normal [21]. In the modified Weaver-Dunn technique, suture, tape, or a screw is used to keep the acromioclavicular joint reduced while the transferred ligament heals [22]. Numerous complications including hardware migration, coracoid or clavicular fractures, infection and fixation failure have been reported [22]. The modified Weaver-Dunn procedure also placed the clavicle in a non anatomic position [22]. Aseptic foreign body reaction or infection has been associated with the use of synthetic suture and implants [23]. The hook plate may be used to augment soft tissue reconstruction or may be used in isolation. Unfortunately, it has also been associated with infection, plate dislocation and becoming bent [19]. When an autologous graft is used, there is no risk of foreign body tissue reaction to synthetic materials. Potential complications of implants are avoided and a second operation for removal of hardware is unnecessary [24].

The search for stable and anatomic CC reconstruction techniques has resulted in using free tendon grafts [25].

Reconstruction of the injured ligaments offers a biological option by getting incorporated into living tissue [17]. If an auto graft is selected, donor site morbidity may occur [17, 18]. Donor site morbidity is uncommon however [25, 26]. Allograft has been used in acute and chronic cases with excellent functional results [27]. Anatomic reconstruction with semitendinosus allograft has been shown in a cadaver study to be biomechanically superior to non anatomic allograft reconstruction, anatomic suture fixation, graftrope reconstruction and the modified Weaver-Dunn techniques [26]. If allograft is used however, disease transmission may occur (17).

Lee et al [18] found that reconstruction with semitendinosus (ST), gracilis or long toe extensor grafts had superior initial biomechanical properties compared with coracoacromial ligament transfer during non-cyclical loading. There were no differences in strength and stiffness noted between the three graft choices [18].

Semitendinosus reconstruction does not require the use of the coracoacromial ligament allowing it to maintain its function as a humeral head stabiliser. It does not rely on native ligaments to heal and may promote earlier aggressive rehabilitation and earlier return to work [17]. The strength of the reconstruction plus the primary healing of the torn native CC ligaments may yield a higher strength than any of the repairs that rely on primary healing alone [18].

Lizaur [28] emphasized that repair of CC ligaments had no bearing on the final stability of the clavicle. He deemed that repair of the deltotrapeziod muscle complex is an important surgical adjunct.

Ceccarelli [10] performed an extensive literature search on the management of Type III injuries. He found that there were an inadequate number of randomised controlled trials or complete systematic reviews. Studies lacked validated outcome measures and comparison between the few randomised controlled trials was not possible. He felt that there was no overwhelming evidence to offer surgery as first line treatment of these injuries (10). It is difficult to analyse the numerous studies over the past three decades which lack prospective designs and compare multiple treatments [11]. The decision to use a given method of treatment is often based on dogma and anecdotal experience [11].

Stiffness of the CC suspension is the determining factor for good functional outcome. The ST graft offers more stability with significantly less amount of CC displacement under stress loading, resulting in better clinical outcome [26]. The expanding body of biomechanical studies to date supports individual reconstruction of the CC and AC ligaments [26].

Domos et al (29) in a 2017 study conducted a survey amongst UK Orthopaedic surgeons collecting 137 responses in 3 months. They all opted for initial conservative management with 86% of the responders ordered commencing of routine physiotherapy. Pre injury demands, current pain and disability were considerations for converting to surgical management. The lockdown technique was the most common technique used. For acute cases, the next commonest procedure was ligament augmentation and reconstruction system, the hook plate, then the arthroscopic tightrope technique. These techniques which uses a foreign body, allow for an accurate reduction of the ACJ, without the donor site morbidity associated with using autogenous grafts.

Korsten et al (30) underwent a critical appraisal of eight articles after doing a systematic literature review. Subjective and objective shoulder function was superior in the operative group, especially in young adults, but the complication rates in conjunction with radiographic abnormalities were higher. The rehabilitation time was shorter in the conservative group; but there were inferior cosmetic results. Korstens' conclusion was that there were no major differences in outcome between operative and nonoperative cases.

IV. Conclusion

The literature remains ambiguous as to the superiority of surgical management over conservative management for Type III ACJ dislocations. However, reconstruction may provide excellent function and patient satisfaction with appropriate patient selection.

References Références Referencias

1. Mazzocca, AD., Arciero, RA., Bicos, J. (2007). Evaluation and Treatment of Acromioclavicular Joint Injuries. *Am J Sports Med.*, 35(2): 316-329.
2. Lemos, MJ. (1998). The evaluation and treatment of the injured acromioclavicular joint in athletes. *Am J Sports Med.*, 26(1): 137-44.
3. Costic, RS., Labriola, JE., Rodosky, MW., Debski, RE. (2004). Biomechanical rationale for development of anatomical reconstructions of coracoclavicular ligaments after complete acromioclavicular joint dislocations. *Am J Sports Med.,* 32(8): 1929-36.
4. Lee, KW., Debski, RE., Chen, CH., Woo, SL., Fu, FH. (1997). Functional evaluation of the ligaments at the acromioclavicular joint during anteroposterior and superoinferior translation. *Am J Sports Med.*, 25(6): 858-62.
5. Tossy, JD., Mead, NC., Sigmond, HM. (1963). Acromioclavicular separations: useful and practical classification for treatment. *Clin Orthop Relat Res.*, 28: 111-9.
6. Rockwood, CJ., Williams, G., Young, D: (1998). Disorders of the acromioclavicular joint. *In The shoulder.* 2nd edition. Edited by: Rockwood CJ, Matsen FA. Philadelphia, PA, USA: WB Saunders; 483-553.
7. Fukuda, K., Craig, EV., An, KN., Cofield, RH., Chao, EY. (1986). Biomechanical study of the ligamentous system of the acromioclavicular joint. *J Bone Joint Surg Am.,* 68(3): 434-40.
8. Goss, TP. (1993). Double disruptions of the superior shoulder suspensory complex. *J Orthop Trauma.,* 7 (2): 99-106.
9. Fraser-Moodie, JA., Shortt, NL., Robinson, CM. (2008). Injuries to the acromioclavicular joint. *J Bone Joint Surg Br.*, 90(6): 697-707.
10. Ceccarelli, E., Bondi, R., Alviti, F. (2008).Treatment of acute grade III acromioclavicular dislocation:a lack of evidence. *J Orthopaed Traumatol,*) 9: 105-108
11. Schlegel, TF., Burks, RT., Marcus, RL. (2001). A prospective evaluation of untreated acute grade III acromioclavicular separations. *Am J Sports Med.*, 29(6): 699-703.
12. Bannister, GC., Wallace, WA., Stableforth, PG., Hutson, MA. (1989). The management of acute acromioclavicular dislocation. A randomised prospective controlled trial. *J Bone Joint Surg Br.,* 71(5): 848-50.
13. Dias, JJ., Steingold, RF., Richardson, RA., Tesfayohannes, B., Gregg, PJ. The conservative treatment of acromioclavicular dislocation. *J Bone Joint Surg,*; 69-B : 719-722.
14. Fremerey, R., Freitag, N., Bosch, U. (2005). Complete dislocation of the acromioclavicular joint: operative versus conservative treatment. *J. Orthopaed Traumatol.*, 6(4): 174-178.
15. Kumar, S., Penematsa, SR., Selvan, T. (2007). Surgical reconstruction for chronic painful acromioclavicular joint dislocations. *Arch Orthop Trauma Surg.*, 127(6): 481-4.
16. Guy, DK., Wirth, MA., Griffin, JL., Rockwood, CA. Jr. (1998). Reconstruction of chronic and complete dislocations of the acromioclavicular joint. *Clin Orthop Relat Res.,* (347): 138-49.
17. Lee, SJ., Keefer, EP., McHugh, MP., Kremenic, IJ., Orishimo, KF., Ben-Avi, S., et al. (2008). Cyclical loading of coracoclavicular ligament reconstructions: a comparative biomechanical study. *Am J Sports Med.*, 36(10): 1990-7.
18. Lee, SJ., Nicholas, SJ., Akizuki, KH., McHugh, MP., Kremenic, IJ., Ben-Avi S. (2003). Reconstruction of the coracoclavicular ligaments with tendon grafts: a comparative biomechanical study. *Am J Sports Med.*, 31(5): 648-55.
19. Faraj, AA., Ketzer, B. (2001). The use of the hook plate in the management of acromioclavicular injuries: report of ten cases. *Acta Orthop Belg,* 67: 448-451
20. Lee, TQ., Black, AD., Tibone, JE., McMahon, PJ. (2001). Release of the coracoacromial ligament can lead to glenohumeral laxity: a biomechanical study. *J Shoulder Elbow Surg.,* 10(1): 68-72.
21. Deshmukh, AV., Wilson, DR., Zilberfarb, JL. (2004). Stability of acromioclavicular joint reconstruction: biomechanical testing of various surgical techniques on a caderveric model. *Am J Sports Med.*, 32(6): 1492-1498
22. Mazzocca, A., Conway, JE., Johnson, S. (2004). The anatomic coracoclavicular ligament reconstruction. Operative techniques in sports medicine, *Am J Sports Med.,12 (1)*: 55-61
23. Simovitch, R., Sanders, B., Ozbaydar, M. (2009). Acromioclavicular joint injuries: diagnosis and management *J AM Acad Orthop Surg.,*17: 207-219
24. Jones, HP., Lemos, MJ., Schepsis, AA. (2001). Salvage of failed acromioclavicular joint reconstruction using autogenous semitendinosus tendon from the knee. Surgical technique and case report. *Am J Sports Med.*, 29(2): 234-7.
25. Tauber, M., Gordon, K,, Kollerm H,, Fox, M., Resch, H. (2009). Semitendinosus tendon graft versus a modified Weaver-Dunn procedure for acromioclavicular joint reconstruction in chronic cases: a prospective comparative study. *Am J Sports Med.*, 37(1): 181-90. Epub 2008 Sep 25.
26. Nicholas, SJ., Lee, SJ., Mullaney, MJ., Tyler, TF., McHugh, MP. (2007). Clinical outcomes of coracoclavicular ligament reconstructions using tendon grafts. *Am J Sports Med.* 35(11): 1912-7.
27. Thomas, K., Litsky, A., Jones, G. (2011). Biomechanical comparison of coracoclavicular

reconstructive techniques. *Am J Sorts Med.,* 39(4): 804-810

28. Lizaur, A., Marco, L., Cebrian, R. (1994). Acute dislocation of the acromioclavicular joint. *J bone Joint Surg (Br)*. 76(4): 602-606.

29. Domos, P., Sim, F., Dunne M., White, A. (2017). Current practice in the management of Rockwood type III acromioclavicular joint dislocations-national survey. *Journal of Orthopaedic Surgery* https://doi. Org/10.1177/2309499017717868.

30. Korsten, K., Gunning, A. C., & Leenen, L. P. H. (2014). Operative or conservative treatment in patients with Rockwood type III acromioclavicular dislocation: a systematic review and update of current literature. *International Orthopaedics*, *38* (4), 831–838.