

Sternoclavicular joint injuries: a literature review

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Summary

Traumatic sternoclavicular (SC) joint injuries are rare. The goal of this literature review was to evaluate the available literature on the treatment of traumatic anterior and posterior SC (fracture-) dislocations in adults and children.

In adults, anterior dislocations are most commonly treated by nonoperative means. Closed reduction can be attempted but is associated with a high recurrence rate. For posterior dislocations, closed reduction is usually more successful.

Children usually present with displaced physal fractures, as true dislocations probably do not occur in a skeletally immature population. Anterior displacement can easily be reduced but it is difficult, if not impossible, to maintain the reduction. In contrast with the recommendations in adults, ORIF with the use of absorbable sutures can be indicated in these cases. No consensus exists on the recurrence of posterior displacement after closed reduction. If closed reductions fails, operative treatment is indicated, using the same technique as in anterior displacement.

Key words: sternoclavicular, dislocation, physal fracture, anterior, posterior

Introduction

The sternoclavicular (SC) joint is a point of articulation between the upper extremity and the axial skeleton. It is classified as a double arthrodiar synovial joint, and is reported to have little intrinsic stability (1). The joint is formed by the sternal end of the clavicle, the clavicular notch of the manubrium and the cartilage of the first rib (2-4). The clavicle is the first long bone to ossify. However, the epiphysis at the medial end of the clavicle is the last of the long bones to appear and is the last epiphy-

sis to close. It does not ossify until age 18 to 20 years. The epiphysis does not fuse with the shaft of the clavicle until age 23 to 25 years (5). Until then, the growth plate remains the weakest point and more likely to sustain a displaced physal fracture than a true dislocation. Ligamentous structures in this region include the anterior and posterior SC ligaments, the costoclavicular (CC) ligament, and the interclavicular ligament (2-4, 6). The posterior capsule is the most important restraint for anterior and posterior translation of the SC joint. The anterior capsule is another important restraint for anterior translation. The CC and interclavicular ligaments have little effect on anterior or posterior translation of the SC joint (7).

Traumatic SC joint injuries account for less than 3% of all traumatic joint injuries (8). They have been classified according to patient age, severity and, in the setting of a dislocation, the direction of the sternal end of the clavicle. Anterior dislocations are two to three times more common than posterior dislocations, and fortunately they are less dangerous (9).

The goal of this literature review was to evaluate the available literature on the treatment of traumatic SC dislocations.

Methods

A search of the National Library of Medicine database (Medline), PubMed and EMBASE was conducted for English-language articles published between 1925 and September 2011, using the following medical subject headings or their equivalents: "sternoclavicular dislocation", "anterior", "posterior", "closed reduction", and "operative treatment". The reference lists of the identified papers as well as their publisher databases were further scanned for additional relevant citations. This search retrieved over 400 potentially eligible studies, which were selected by title and abstract. If the title or the abstract was insufficient to reach a final decision, we reviewed the full paper. Finally, a total of 41 publications relevant to the topic and meeting the inclusion criteria were included.

Results

General

Several treatment options have been proposed to address acute and chronic symptomatic SC dislocations (10-50). In general, anterior dislocation can be treated with closed reduction. If closed reduction fails a conservative treatment is proposed. Concerning the treatment of posterior dislocation, also closed reduction is the first treatment option. In contrast with an anterior SC dislocation, failed closed reduction of a posterior SC

dislocation is an indication for operative treatment in the acute setting. If operative treatment is indicated, it usually involves open reduction and repair or reconstruction of one or several ligaments. Medial clavicle excisions with or without ligament reconstruction or other surgical techniques have also been described to treat these injuries. In children, the differential diagnosis between SC dislocation and physeal separation is often difficult to make (44-46). Before fusion, the medial physis is the weakest part of the medial clavicle and is more susceptible to fracture than the SCJ is to dislocation. In literature a postoperative figure-of-eight bandage is prescribed after closed reduction, although a beneficial effect on the stability of the joint has not yet been documented in the literature.

Traumatic anterior dislocation in adults

Closed reduction

Closed reduction of an anterior SC dislocation is usually easy to achieve. The patient is placed supine on the table, with a small sandbag between the shoulders. In this position, the joint may reduce with direct gentle pressure over the anteriorly displaced clavicle.

According to Savastano et al., closed reduction should not be performed in an acute setting because stability of the SC joint is not necessary to ensure normal function of the involved limb (34). De Jong et al. reported on ten patients with acute SC dislocations who were treated conservatively without closed reduction (20). The results of treatment were good in seven patients, fair in two patients, and poor in one patient. Others attempted closed reduction with varying success. They had recurrence rates between 21 and 100% (17, 35, 36). Eskola described the results achieved in eight patients treated with closed reduction (17). Redislocation occurred in five of them, and was painful in three patients, two of whom were operated on. Nettles et al. obtained better results: of sixteen patients treated with closed reduction, eleven had no recurrence and no pain. Three had a redislocation and two were lost to follow-up (36). If closed reduction is successful, cosmesis is improved (8).

Operative treatment

Several options for operative treatment of acute and chronic anterior SC dislocations have been proposed in the literature. These can be categorized into four commonly described techniques that can be used in isolation or together. The first option is suturing of SC ligaments and CC ligaments. This is the only technique described in the literature for acute cases (17, 37, 38). Witvoet et al. and Eskola performed an open reduction with suturing of ligaments and capsule, together with temporary fixation with two K-wires (17, 37). Lehmann et al. used a suture anchor that was placed in the sternum (38). In total, the results in seven patients with an acute dislocation were good, without any complication (17, 37, 38).

The second technique, most extensively documented for chronic symptomatic anterior SC dislocation involves reconstruction of the anterior SC ligament (10-12, 26, 27, 39, 40). Different autografts have been proposed to reconstruct the ligament. The earliest reports concerned the use of fascia lata (10-12). In 2004, Spencer et al. (40) stated that the use of a semitendinosus graft in a fi-

gure-of-eight configuration provides initial biomechanical properties that are superior to those obtained with other known techniques for treating chronic SC dislocation. In 2008, Castopril et al. (27) used this technique in an athlete, with good results. Armstrong et al. (26) and Lee et al. (39) successfully used the medial portion of the sternal part of the sternocleidomastoid muscle.

The third treatment option is to reconstruct the CC ligament. With this technique also, different autografts have been used to reconstruct the ligament. In 1928, Allen (10) proposed to use a fascia lata graft, but fixed the clavicle to the second rib. In 1951, Burrows (13) performed a transposition of subclavius muscle. Lunseth used the same technique but with a temporary additional fixation with a Steinmann pin (14). Tenodesis of the sternal head of the sternocleidomastoideus muscle has also been used with success to reconstruct the CC ligament (41). All these techniques have been studied in small groups of patients, and have been found to provide favourable results.

The fourth option is resection of the medial clavicle. However, because the results are less than positive, this option is not recommended anymore (19, 23, 42, 43). If a resection is performed, an intramedullary reconstruction is proposed (23).

In the literature, a few techniques other than those mentioned above, have been described. Franck et al. achieved good results with Balser plate stabilization in six patients with acute anterior SC dislocation (24). This treatment modality has the same background as the use of a hook plate in acute AC dislocations (51). Disadvantages are the dimensions of the Balser plate and the need for implant removal after 3 months. Chen et al. successfully used tension band wiring and K-wire fixation in 8 patients, but found this technique to have several drawbacks (33). In other articles K-wire fixation is not recommended because of the high risk of intrathoracic migration and possible to the mediastinal structures that can cause fatal injuries (52-54).

After treatment

Concerning aftertreatment, a figure-of-8 clavicle splint (8, 24) or a Velpeau dressing (17, 26, 27) is proposed for 3-4 (8, 17) or 6 weeks (26). As mentioned, a beneficial effect of the slings on the stability of the joint has not yet been documented in the literature. Patients should not elevate the arm $\geq 60^\circ$ during this time and should use the extremity only for hygiene. After 12 weeks, patients may gradually increase the use of the arm for activities of daily living (8).

Traumatic anterior (fracture-) dislocation in children

As described, the differential diagnosis between SC dislocation and physeal separation is often difficult to make in children (44-46). Probably, a true anterior dislocation in a child does not exist.

Closed reduction

Closed reduction and immobilization has been proposed as the first treatment option for anterior-fracture dislocation (55). However, although they are easily reducible it is difficult if not impossible to maintain the reduction (45, 56).

Operative treatment

If closed reduction fails, some authors propose surgical treatment (45, 47, 56). It consists of open anatomical re-

duction and internal fixation either by nonabsorbable suture material, as proposed by Simurda (47), or by a Vicryl sling placed around the first rib (45). The functional results are excellent, with a full range of motion, unrestricted sports activity, and no pain. Alternatively, transarticular K-wire fixation to fortify the periosteal suture has been proposed (56), but is no longer recommended. The only significant disadvantage of operative treatment is a potentially disfiguring hypertrophic scar.

After treatment

As in adults, a figure-of-eight sling is proposed for 3–4 weeks in closed (45) and open reduction (8).

Traumatic posterior dislocation in adults

Traumatic posterior SC dislocations are rare, but complications are more common than after anterior dislocations (57). They include brachial plexus lesions (58, 59), pneumothorax and respiratory distress (21, 60), vascular injury (59, 61, 62), dysphagia and hoarseness (62, 63).

Closed reduction

Two different techniques of closed reduction have been described. The most common technique is the abduction traction technique (32), in which the patient is positioned supine with the dislocated shoulder near the edge of the table and a small sandbag between the shoulders. Lateral traction is applied to the abducted arm, which is then gradually brought back into extension. Importantly, traction should always precede extension of the arm to prevent the anterior aspect of the medial clavicle from binding on the posterior surface of the manubrium. If this technique is unsuccessful, a sterile towel clip can be used to facilitate the reduction by encircling the medial clavicle and applying lateral and anterior traction.

Using the abduction traction technique, Groh et al. achieved closed reduction in 11 out of 12 patients if performed at a maximum of 10 days postinjury. In two patients, a sterile towel clip had to be used. Eight patients had excellent results and three patients subsequently had recurrent posterior dislocations (32).

The other technique is using the levering principle. In this technique the patient is also positioned supine. Caudal traction is applied to the adducted arm while both shoulders are forced posteriorly by direct pressure (16).

Applying this technique at a maximum of 3 days postinjury, Buckerfield and Castle achieved closed reduction of a traumatic posterior SC dislocation or posterior physeal fracture-dislocation in 6 of 7 patients ranging in age from 13 to 26 years (it was not possible to differentiate the children from the adults) (16).

Laffosse et al. reported their experience with posterior SC injuries and successfully performed closed reduction in 5 out of 10 cases (28).

Operative treatment

In contrast with an anterior SC dislocation, failed closed reduction of a posterior SC dislocation is an indication for operative treatment in the acute setting. The same may also apply to a chronic posterior SC dislocation. Most techniques for the treatment of anterior SC dislocations can also be used for posterior SC dislocations (28, 32, 33). Franck also described his alternative tech-

nique with the use of a Bessler plate, for posterior dislocation. In contrast to the retrosternal position in anterior dislocation the plate is positioned introsternally (24). Some other techniques that have not been used to treat anterior SC dislocations have been proposed for patients with posterior dislocations. Shuler et al. performed locking plate osteosynthesis in two patients, with good results (48). Brinker et al. used 2 cannulated screws for temporary fixation/stabilization of the joint (3 months), with good results in two patients (22).

After treatment

Post reduction, the use of a figure-of-8 dressing is proposed for 6 to 8 weeks (16, 32).

Traumatic posterior (fracture-) dislocation in children

Posterior dislocations of the SC joint in children should be treated as a separate entity due to ongoing growth at the epiphysis (30). As described previously, it is very difficult to distinguish between true dislocation and displacement of the medial clavicle physeal fracture. The diagnosis of posterior dislocation of the medial clavicle in patients under age 25 requires a high index of suspicion for physeal fracture (64, 65).

Closed reduction

Gobet et al. achieved closed reduction in two of three patients with posterior fracture dislocations (45). Yang et al. successfully managed 4 cases of posterior dislocation in children with closed reduction (49). This is in contrast with Laffosse et al. who reported a systematic failure of attempted closed reduction (28). Garg et al. described a case of failed closed reduction 1 week postinjury (30). Waters et al. had three cases of failed closed reduction and proposed to perform immediate open reduction and fixation (50).

Operative treatment

If closed reduction fails, open reduction and internal fixation (ORIF) is proposed (28, 30, 50). In their series of 13 cases, Waters et al., successfully used No.1 polyester sutures to repair CC and SC ligaments (50). Garg et al. used a similar technique, with good results (30). Laffosse et al. used PDS sutures for CC ligament repair and CC cerclage (28).

After treatment

Closed reduction can be maintained with a figure-of-eight bandage (49).

Postoperatively a sling-and-swathe is also proposed for a total of 3-4 weeks (30, 50).

Spontaneous anterior dislocation in adults

Spontaneous atraumatic anterior subluxation of the sternoclavicular joint may occur during overhead elevation of the arm. Affected patients are generally in their teens or twenties, and many demonstrate signs of generalized ligamentous laxity on physical examination. Patients report a sudden subluxation of the medial end of the clavicle, and many remember feeling an associated pop. The majority of the cases are not painful, and the subluxation usually reduces with lowering the arm (66). Since spontaneous atraumatic anterior subluxation of the sternoclavicular joint has a benign natural course, it should

not be treated with operative stabilization of the joint. Instead, a conservative approach that includes education and reassurance of the patient will result in an unaltered lifestyle with no limitation of activity and little or no discomfort (67).

Discussion

Sternoclavicular injuries are rare but can be associated with serious short and long-term complications (8). Anterior dislocations in adults are most commonly treated by nonoperative means (31). These injuries are typically unstable even after reduction but are well tolerated by patients. Closed reduction is associated with a recurrence rate between 21 and 100% (17, 35, 36). Posterior sternoclavicular dislocations can be immediately associated with pneumothorax, laceration or occlusion of the great vessels, rupture of the esophagus, brachial plexus compression, and recurrent laryngeal nerve injury. For posterior dislocations in adults, closed reduction is usually attempted (31). In contrast to anterior dislocations, acute posterior dislocations are typically amenable to closed reduction and are stable after reduction. Because of the possibility of late onset of life-threatening complications, all unreduced posterior dislocations should be surgically reduced. Based on the low number of reported open reduction cases in the literature, tenodesis, suture fixation, and ORIF have the highest percentage of excellent/good results in adults, without frequently associated high-risk complications. Resection of the medial clavicle and tendon graft has the lowest percentage of excellent/good results, and K-wire/pin fixation is associated with dangerous complications such as wire and pin migrations or breakages (31).

Children usually present displaced physal fractures, as true dislocations probably do not occur in a skeletally immature population. Anterior displacement can easily be reduced but it is difficult if not impossible to maintain the reduction. In contrast with the recommendations in adults, ORIF with the use of absorbable sutures is indicated in these cases. No consensus exists on the recurrence of posterior displacement after closed reduction. If closed reductions fails, operative treatment is indicated, using the same technique as in anterior displacement. Concerning aftertreatment, a figure-of eight bandage or a sling is proposed in all situations. But it is not clear if the figure-of-eight gives a beneficial effect on the stability of the joint.

Spontaneous atraumatic anterior subluxation of the sternoclavicular joint has a benign natural course and it should be treated conservatively.

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References

1. Jazrawi L, Rokito A, Birdzell M, Zuckerman J. Biomechanics of the shoulder. third ed. Nordin M, Frankel V, editors. Philadelphia (PA) Lippincott Williams and Wilkins; 2001.

2. Brossmann J, Stabler A, Preidler KW, Trudell D, Resnick D. Sternoclavicular joint: MR imaging-anatomic correlation. *Radiology*. 1996 Jan;198(1):193-198.
3. Barbaix E, Lapiere M, Van Roy P, Clarijs JP. The sternoclavicular joint: variants of the discus articularis. *Clin Biomech (Bristol, Avon)*. 2000;15 Suppl 1:S3-7.
4. Emura K, Arakawa T, Terashima T, Miki A. Macroscopic and histological observations on the human sternoclavicular joint disc. *Anat Sci Int*. 2009 Sep;84(3):182-188.
5. Webb PA, Suchey JM. Epiphyseal union of the anterior iliac crest and medial clavicle in a modern multiracial sample of American males and females. *Am J Phys Anthropol*. 1985 Dec;68(4):457-466.
6. Tubbs RS, Loukas M, Slaphey JB, McEvoy WC, Linganna S, Shoja MM, et al. Surgical and clinical anatomy of the interclavicular ligament. *Surg Radiol Anat*. 2007 Jul;29(5):357-360.
7. Spencer EE, Kuhn JE, Huston LJ, Carpenter JE, Hughes RE. Ligamentous restraints to anterior and posterior translation of the sternoclavicular joint. *J Shoulder Elbow Surg*. 2002 Jan-Feb;11(1):43-47.
8. Groh GI, Wirth MA. Management of traumatic sternoclavicular joint injuries. *J Am Acad Orthop Surg*. 2011 Jan;19(1):1-7.
9. Bahk MS, Kuhn JE, Galatz LM, Connor PM, Williams GR, Jr. Acromioclavicular and sternoclavicular injuries and clavicular, glenoid, and scapular fractures. *J Bone Joint Surg Am*. 2009 Oct;91(10):2492-2510.
10. Allen AW. Living suture grafts in the repair of fractures and dislocations. *Arch Surg*. 1928 May 1, 1928;16(5):1007-1020.
11. Lowman CL. Operative correction of old sternoclavicular dislocation. *J Bone Joint Surg Am*. 1928 October 1, 1928;10(4):740-741.
12. Bankart ASB. An operation for recurrent dislocation (subluxation) of the sternoclavicular joint. *British Journal of Surgery*. 1938;26:320-323.
13. Burrows HJ. Tenodesis of subclavius in the treatment of recurrent dislocation of the sterno-clavicular joint. *J Bone Joint Surg Br*. 1951 May;33B(2): 240-243.
14. Lunseth PA, Chapman KW, Frankel VH. Surgical treatment of chronic dislocation of the sterno-clavicular joint. *J Bone Joint Surg Br*. 1975 May;57(2):193-196.
15. Barth E, Hagen R. Surgical treatment of dislocations of the sternoclavicular joint. *Acta Orthop Scand*. 1983 Oct;54(5):746-753.
16. Buckerfield CT, Castle ME. Acute traumatic retrosternal dislocation of the clavicle. *J Bone Joint Surg Am*. 1984 Mar;66(3):379-385.
17. Eskola A. Sternoclavicular dislocation. A plea for open treatment. *Acta Orthop Scand*. 1986 Jun;57(3):227-228.
18. Fery A, Sommelet J. [Sternoclavicular dislocations. Observations on the treatment and result of 49 cases]. *Int Orthop*. 1988;12(3):187-195.
19. Eskola A, Vainionpaa S, Vastamaki M, Slatis P, Rokkanen P. Operation for old sternoclavicular dislocation. Results in 12 cases. *J Bone Joint Surg Br*. 1989 Jan;71(1):63-65.
20. de Jong KP, Sukul DM. Anterior sternoclavicular dislocation: a long-term follow-up study. *J Orthop Trauma*. 1990;4(4):420-423.

21. Gale DW, Dunn ID, McPherson S, Oni OO. Retrosternal dislocation of the clavicle: the 'stealth' dislocation. *Injury*. 1992;23(8):563-564.
22. Brinker MR, Bartz RL, Reardon PR, Reardon MJ. A method for open reduction and internal fixation of the unstable posterior sternoclavicular joint dislocation. *J Orthop Trauma*. 1997 Jul;11(5):378-381.
23. Rockwood CA, Jr., Groh GI, Wirth MA, Grassi FA. Resection arthroplasty of the sternoclavicular joint. *J Bone Joint Surg Am*. 1997 Mar;79(3):387-393.
24. Franck WM, Jannasch O, Siassi M, Hennig FF. Balser plate stabilization: an alternate therapy for traumatic sternoclavicular instability. *J Shoulder Elbow Surg*. 2003 May-Jun;12(3):276-281.
25. Abiddin Z, Sinopidis C, Grocock CJ, Yin Q, Frostick SP. Suture anchors for treatment of sternoclavicular joint instability. *J Shoulder Elbow Surg*. 2006 May-Jun;15(3):315-318.
26. Armstrong AL, Dias JJ. Reconstruction for instability of the sternoclavicular joint using the tendon of the sternocleidomastoid muscle. *J Bone Joint Surg Br*. 2008 May;90(5):610-613.
27. Castropil W, Ramadan LB, Bitar AC, Schor B, de Oliveira D'Elia C. Sternoclavicular dislocation--reconstruction with semitendinosus tendon autograft: a case report. *Knee Surg Sports Traumatol Arthrosc*. 2008 Sep;16(9):865-868.
28. Laffosse JM, Espie A, Bonnevalle N, Mansat P, Tricoire JL, Bonnevalle P, et al. Posterior dislocation of the sternoclavicular joint and epiphyseal disruption of the medial clavicle with posterior displacement in sports participants. *J Bone Joint Surg Br*. 2010 Jan;92(1):103-109.
29. Rotini R, Guerra E, Bettelli G, Marinelli A, Frisoni T. Sterno clavicular joint dislocation: a case report of a surgical stabilization technique. *Musculoskeletal Surgery*. 2010;94(0):91-94.
30. Garg S, Alshameeri ZA, Wallace WA. Posterior sternoclavicular joint dislocation in a child: a case report with review of literature. *J Shoulder Elbow Surg*. 2011 Oct 15.
31. Glass ER, Thompson JD, Cole PA, Gause TM, 2nd, Altman GT. Treatment of sternoclavicular joint dislocations: a systematic review of 251 dislocations in 24 case series. *J Trauma*. 2011 May;70(5):1294-1298.
32. Groh GI, Wirth MA, Rockwood CA, Jr. Treatment of traumatic posterior sternoclavicular dislocations. *J Shoulder Elbow Surg*. 2011 Jan;20(1):107-113.
33. Chen QY, Cheng SW, Wang W, Lin ZQ, Zhang W, Kou DQ, et al. K-wire and tension band wire fixation in treating sternoclavicular joint dislocation. *Chin J Traumatol*. 2011 Feb 1;14(1):53-57.
34. Savastano AA, Stutz SJ. Traumatic sternoclavicular dislocation. *Int Surg*. 1978 Jan;63(1):10-13.
35. Salvatore JE. Sternoclavicular joint dislocation. *Clin Orthop Relat Res*. 1968 May-Jun;58:51-55.
36. Nettles JL, Linscheid RL. Sternoclavicular dislocations. *J Trauma*. 1968 Mar;8(2):158-164.
37. Witvoet J, Martinez B. [Treatment of anterior sternoclavicular dislocations. Apropos of 18 cases]. *Rev Chir Orthop Reparatrice Appar Mot*. 1982; 68(5):311-316.
38. Lehmann W, Laskowski J, Grossterlinden L, Rueger JM. [Refixation of sternoclavicular luxation with a suture anchor system]. *Unfallchirurg*. 2010 May;113(5):418-421.
39. Lee SU, Park IJ, Kim YC, Jeong C. Stabilization for chronic sternoclavicular joint instability. *Knee Surg Sports Traumatol Arthrosc*. 2010 Dec;18(12):1795-1797.
40. Spencer EE, Jr., Kuhn JE. Biomechanical analysis of reconstructions for sternoclavicular joint instability. *J Bone Joint Surg Am*. 2004 Jan;86-A(1):98-105.
41. Booth CM, Roper BA. Chronic dislocation of the sternoclavicular joint: an operative repair. *Clin Orthop Relat Res*. 1979 May(140):17-20.
42. Acus RW, 3rd, Bell RH, Fisher DL. Proximal clavicle excision: an analysis of results. *J Shoulder Elbow Surg*. 1995 May-Jun;4(3):182-187.
43. Panzica M, Zeichen J, Hankemeier S, Gaulke R, Krettek C, Jagodzinski M. Long-term outcome after joint reconstruction or medial resection arthroplasty for anterior SCJ instability. *Arch Orthop Trauma Surg*. 2010 May;130(5):657-665.
44. El Mekkaoui MJ, Sekkach N, Bazeli A, Faustin JM. Proximal clavicle physeal fracture-separation mimicking an anterior sterno-clavicular dislocation. *Orthop Traumatol Surg Res*. 2011 May;97(3):349-352.
45. Gobet R, Meuli M, Altermatt S, Jenni V, Willi UV. Medial clavicular epiphysiolysis in children: the so-called sterno-clavicular dislocation. *Emerg Radiol*. 2004 Apr;10(5):252-255.
46. Brinker MR, Simon RG. Pseudo-dislocation of the sternoclavicular joint. *J Orthop Trauma*. 1999 Mar-Apr;13(3):222-225.
47. Simurda MA. Retrosternal dislocation of the clavicle: a report of four cases and a method of repair. *Can J Surg*. 1968 Oct;11(4):487-490.
48. Shuler FD, Pappas N. Treatment of posterior sternoclavicular dislocation with locking plate osteosynthesis. *Orthopedics*. 2008 Mar;31(3):273.
49. Yang J, al-Etani H, Letts M. Diagnosis and treatment of posterior sternoclavicular joint dislocations in children. *Am J Orthop (Belle Mead NJ)*. 1996 Aug;25(8):565-569.
50. Waters PM, Bae DS, Kadiyala RK. Short-term outcomes after surgical treatment of traumatic posterior sternoclavicular fracture-dislocations in children and adolescents. *J Pediatr Orthop*. 2003 Jul-Aug;23(4):464-469.
51. Salem KH, Schmelz A. Treatment of Tossy III acromioclavicular joint injuries using hook plates and ligament suture. *J Orthop Trauma*. 2009 Sep;23(8):565-569.
52. Ferrandez L, Yubero J, Usabiaga J, No L, Martin F. Sternoclavicular dislocation. Treatment and complications. *Ital J Orthop Traumatol*. 1988 Sep;14(3):349-355.
53. Clark RL, Milgram JW, Yawn DH. Fatal aortic perforation and cardiac tamponade due to a Kirschner wire migrating from the right sternoclavicular joint. *South Med J*. 1974 Mar;67(3):316-318.
54. Lyons FA, Rockwood CA, Jr. Migration of pins used in operations on the shoulder. *J Bone Joint Surg Am*. 1990 Sep;72(8):1262-1267.
55. Sanders J, Rockwood CJ, Curtis R. Fractures and dislocations of the humeral shaft and shoulder. Rockwood CJ, Wilkins K, Beaty J, editors. Philadelphia: Lippincott-Raven; 1996.

56. Rang M. Children's fractures. Philadelphia: J.B. Lippincott Company; 1974.
57. Worman LW, Leagus C. Intrathoracic injury following retrosternal dislocation of the clavicle. *J Trauma*. 1967 May;7(3):416-423.
58. Jain S, Monbaliu D, Thompson JF. Thoracic outlet syndrome caused by chronic retrosternal dislocation of the clavicle. Successful treatment by transaxillary resection of the first rib. *J Bone Joint Surg Br*. 2002 Jan;84(1):116-118.
59. Howard FM, Shafer SJ. Injuries to the clavicle with neurovascular complications. A study of fourteen cases. *J Bone Joint Surg Am*. 1965 Oct;47(7):1335-1346.
60. Nakayama E, Tanaka T, Noguchi T, Yasuda J, Tera-da Y. Tracheal stenosis caused by retrosternal dislocation of the right clavicle. *Ann Thorac Surg*. 2007 Feb;83(2):685-687.
61. Gardner MA, Bidstrup BP. Intrathoracic great vessel injury resulting from blunt chest trauma associated with posterior dislocation of the sternoclavicular joint. *Aust N Z J Surg*. 1983 Oct;53(5):427-430.
62. Mirza AH, Alam K, Ali A. Posterior sternoclavicular dislocation in a rugby player as a cause of silent vascular compromise: a case report. *Br J Sports Med*. 2005 May;39(5):e28.
63. Borowiecki B, Charow A, Cook W, Rozycki D, Thaler S. An unusual football injury. *Arch Otolaryngol*. 1972 Feb;95(2):185-187.
64. Carbone P, Rose M, O'Daniel JA, Doukas WC, O'Toole RV, Anderson RC. Posterior remodeling of medial clavicle causing superior vena cava impingement. *Am J Orthop (Belle Mead NJ)*. 2011 Jun;40(6):297-300.
65. Renfree KJ, Wright TW. Anatomy and biomechanics of the acromioclavicular and sternoclavicular joints. *Clin Sports Med*. 2003 Apr;22(2):219-237.
66. Bicos J, Nicholson GP. Treatment and results of sternoclavicular joint injuries. *Clin Sports Med*. 2003 Apr;22(2):359-370.
67. Higginbotham TO, Kuhn JE. Atraumatic disorders of the sternoclavicular joint. *J Am Acad Orthop Surg*. 2005 Mar-Apr;13(2):138-145.
68. Rockwood CA, Jr., Odor JM. Spontaneous atraumatic anterior subluxation of the sternoclavicular joint. *J Bone Joint Surg Am*. 1989 Oct;71(9):1280-1288.