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### ***Retrospective analysis of surgical treatments of sternoclavicular joint dislocation: literature review***

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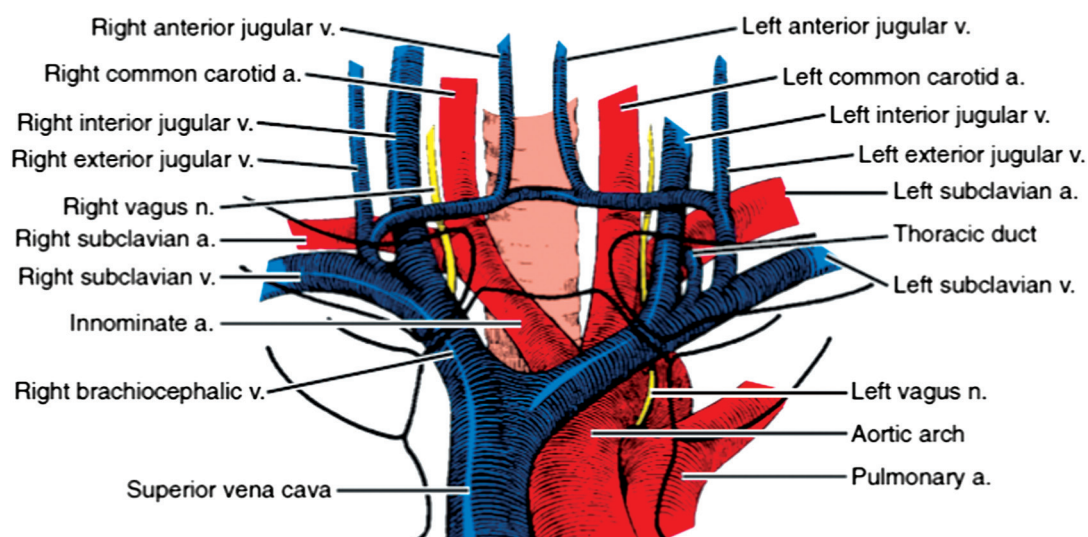
Traumatic injuries to the sternoclavicular joint (SCJ) dislocations account for less than 3% of all joint dislocations. However, instrumentation fixation is frequently associated with high-risk complications that lead to disability. The authors sought to explore historical aspects of various surgical fixation techniques based on specific anatomy of injured segment. The findings are presented in the chronological order briefly describing methods of fixation, the authors and clinical results obtained.

**Keywords:** dislocation, sternoclavicular joint, specific anatomy, fixation, historical aspects

#### INTRODUCTION

Sternoclavicular joint (SCJ) has a double function. On one side, it provides restraint to motion of upper limb girdle and stability, on the other side, helps the arm perform high-amplitude movements. SCJ articulation has a high degree of strength and is supported by strong joint capsule ligaments. Dislocation of the clavicle results from ligament rupture and is not usually accompanied by bone fracture. Anterior dislocations are the most common with the end of the clavicle pushed forward in front of the sternum and posterior dislocations are rare with the end of the clavicle pushed backward

behind the sternum. Anterior dislocation is caused by a high impact trauma to the shoulder and posterior dislocation results from a violent blow to the clavicle. Either dislocation can occur in falls on an outstretched arm. A posterior dislocation requires more urgent medical attention because vital structures (vessels, nerves) behind the SCJ can be compressed leading to life-threatening problems. A detailed understanding of the anatomy of multiple vital structures is of crucial importance for a safe decision making process in the management of SCJ dislocations (**Fig. 1**).



**Fig. 1** Anatomical structures around SCI [1]

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Ligaments of the SCJ include anterior and posterior sternoclavicular ligaments, costoclavicular ligament and interclavicular ligament. The SCJ has an intra-articular disk. Vulnerable structures in the upper mediastinum are localised behind the articulation and operative intervention site including the innominate vein, left subclavian vein, internal and external jugular veins, and left common carotid artery, for left-sided dislocation and innominate vein, right

internal and external jugular veins, innominate artery, for right-sided dislocations. Multiple muscles behind the SCJ – scaleni, sternohyoid, sternothyroid – act as a protective buffer anterior to these vascular structures. The vagus nerve, phrenic nerve, trachea and esophagus are also at significant risk of traumatic injury from posterior SCJ dislocations. Furthermore, the apical parts of the lungs are at risk of traumatic or iatrogenic injury which may result in a pneumothorax.

#### METHODS, DESCRIPTION AND DISCUSSION

SCJ dislocations were first described in 1824 by Sir Astley Paston Cooper, an English surgeon and a pioneer of experimental surgery in his treatise on dislocations and fractures where he reported 120 cases annually observed [2] and it can be considered the first statistical description of this relatively rare injury. Traumatic sternoclavicular joint injuries account for < 3 % of all traumatic joint injuries [3].

The most common causes of sternoclavicular dislocations have been identified in three series [4, 5, 6] conducted by Wirth and Rockwood [7]. The reviews found that 40 % resulted from motor vehicle accidents and 21 % from sports related accidents. The remaining 39 % were associated with miscellaneous trauma, falls and industrial accidents.

The vast majority of SCJ dislocations are anterior and reported to occur in 98 % of the cases in E.F. Cave's series [8] and in 95 % of the cases according to Nettles and Linscheid with sternal end of the clavicle displaced anteriorly causing disruption of the anterior sternoclavicular ligament (an injury to posterior ligament and articular disk can also occur). Posterior SCJ dislocation is a rare occurrence with the end of the clavicle pushed backward behind the sternum causing rupture of the posterior sternoclavicular ligament. Posterior SCJ dislocations are serious injuries due to the proximity of the medial clavicle to the vital structures. Superior sternoclavicular dislocation is an extremely rare injury that can occur in costoclavicular ligament rupture. Infracostal dislocation is an unusual event and considered as a sub-type of anterior dislocation with the medial end of the clavicle hinging over the first rib. Dislocation can be incomplete (subluxation) and complete, acute, recurrent and chronic (delayed) [1].

**Nonoperative treatment.** SCJ injury can be stabilised by closed reduction. De Jong et al. [9] reported ten cases of anterior dislocation treated nonoperatively

with seven good results, two fair results and one poor result. Unfortunately, closed reduction is not satisfying in all the cases [5, 10, 11] with redislocation in 21 to 100 % of the cases. Many authors advocate early surgical treatment for posterior dislocations due to critical structures in the superior mediastinum [10, 12, 13, 14]. Nonoperative treatment is not always more efficacious and reliable than operative treatment. Several surgical techniques are used to address SCJ disruptions. The methods have been grouped by the identity and advantages and disadvantages described for each group.

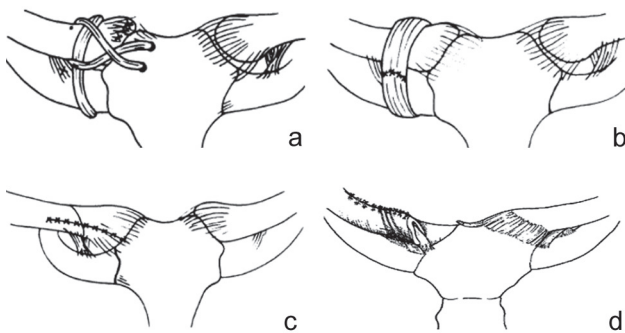
**Local tendon transfers and ligament reconstruction.** In 1951 году Burrows [15] reported a technique involving tenodesis of the subclavius tendon through the medial clavicle with capsulorrhaphy for patients with chronic dislocation. Excellent results were reported in four of five patients, with only one early failure.

Antti Eskola [16] described reconstruction of SCJ using a free tendon graft from the palmaris longus in four cases and plantaris tendon graft in one patient placed from the medial clavicle to the first rib and manubrium (**Fig. 2, a**). In three patients, the clavicle was fixed to the first rib with a fascia lata graft (**Fig. 2, b**). The following score scales were used: subjective function (0 to 2), strength of abduction (0 to 2), pain (0 to 3), instability of the medial end of the clavicle (0 to 2), range of the movement at the shoulder (0 to 3). They reported good results in four patients, three treated with tendon graft and one with a fascia lata graft. Less favourable results were associated with weakness of shoulder abductors, pains during ambulation and decreased range of motion.

**Resection of the medial clavicle.** We think that this is a far less effective technique for SCJ dislocations. Antti Eskola [16] produced subperiosteal resection of the medial end of the clavicle in four cases (**Fig. 2, c**). All the patients suffered pain, and three of

them decreased strength of abduction and limitation in shoulder movement. All four patients gave up work and received full disability pension.

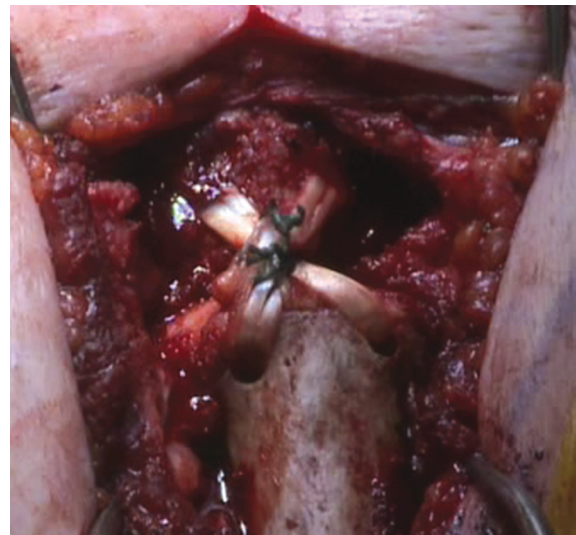
In 1997 Rockwood et al [17] retrospectively analysed two groups of patients consisting of 8 and 7 individuals, correspondingly. Group I underwent similar resection of the medial portion of the clavicle as described by Eskola. Reconstruction of the costoclavicular ligament was added to resection in Group II (**Fig. 2, d**). The pain resolved completely in all but two patients of Group I, who reported slight discomfort during manual labor. Three patients had slight limitation in the performance of strenuous activities or sports requiring overhead motion. Only three patients of Group II had an excellent result. Four patients developed chronic instability in SCJ, excruciating pain and redislocation. Revision procedures were performed for the patients.



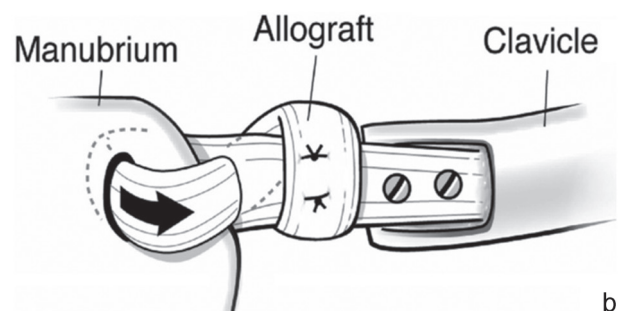
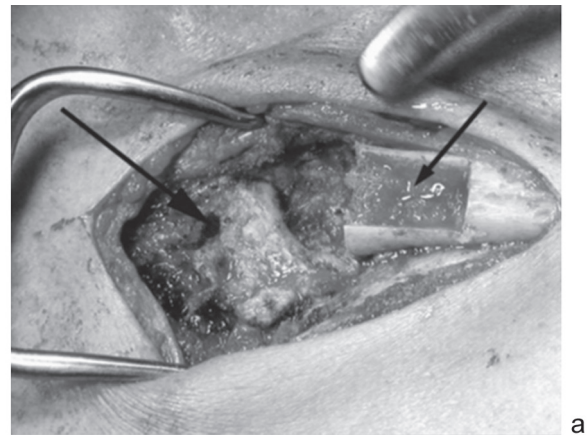
**Fig. 2** Types of resection arthroplasty of SCJ with the clavicle fixed to the first rib and manubrium: a, b, c – [16]; d – [17]

Petri et al [18] reported 21 figure-of-eight reconstructions of the SCJ with hamstring tendon autograft from December 2010 to January 2014 (**Fig. 3**). Nine women and 10 men (2 bilateral cases) with a mean age of 30 years (range, 15-56 years) were monitored for a mean of 2 years (range, 12-36 months) postoperatively. There were no intraoperative and postoperative complications and no cases of recurrent instability. All patients showed improved pain scores and gradually recovered mobility.

Todd et al [19] described an interesting technique using Achilles tendon allograft with resection of the medial portion of the clavicle and screw fixation for unstable SCJ (**Fig. 4**). The procedure was performed in three patients and resulted in function recovery and pain relief in two cases and a good long-term follow-up in one patient with patellar ligament reconstruction.



**Fig. 3** A figure-of-eight reconstructions of the SCJ with hamstring tendon autograft [18]



**Fig. 4** Photograph (a) and diagram (b) of SCJ reconstruction using Achilles tendon allograft with resection of the medial portion of the clavicle and screw fixation

**Treatment of SCJ with metal construct.** Stahel et al. [20] reported bridge plate fixation in a patient with posterior SCJ dislocation using a locking plate (**Fig. 5**). The patient underwent an early hardware removal at 2 months post injury and had uneventful recovery. Within 6 months, he developed excruciating pain over the left SCJ that could not improve with NSAID. A CT scan showed posttraumatic arthritis and posterior subluxation. A ligamentous reconstruction



with allograft tendon led to a good outcome in the patient.



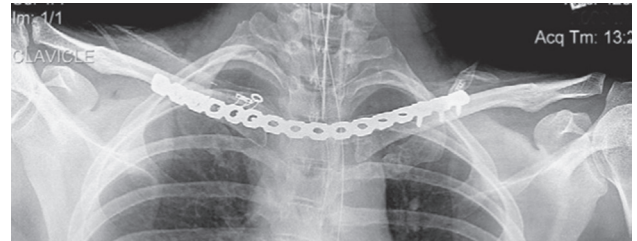
**Fig. 5** Bridge plate fixation of SCJ using a locking plate [20]

Franck et al [21] used Balser plate stabilisation for seven anterior and three posterior SCJ dislocations. Implants were removed after 3 months. One year or longer after the procedure, 9 of 10 patients had excellent results with no cases of redislocation. The only surgical complication was a seroma that required surgical drainage and one patient developed arthrosis (**Fig. 6**). Applying similar technique Hecox and Wood [22] described the usage of 3.5 mm LC/DCP plate LC/DCP (Synthes, West Chester, PA) in 8 patients (5 anterior and 3 posterior dislocations) with good results followed by hardware removal.



**Fig. 6** Arthrodesis with Balcer plate [1]

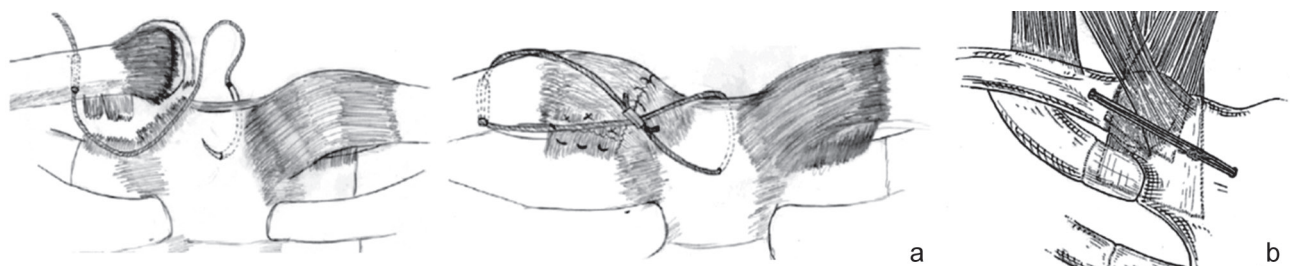
Pensy et al. [23] described a stainless steel reconstruction plate spanning both clavicles and the manubrium for fixation of a posterior SCJ dislocation (**Fig. 7**). The patient had an uncomplicated recovery and the plate and screws were removed at five months in a second procedure.



**Fig. 7** Plate spanning over contralateral clavicle to fix posterior SCJ dislocation [23]

Janson and Rossouw [24] described a new technique with a figure-of-eight sternal tension cable using atraumatic needle Pioneer Sternal Cable System, Marquette MI (**Fig. 8, a**). A figure-of-eight configuration involved the sternal cable passing through the hole drilled in the clavicle and the needle passing through the manubrium to be fastened under tension with the cable tensioning system. Five patients were treated with this technique: two with posterior dislocations and three with anterior injuries. All patients were followed for one year and had good function and stability of the SCJ. Two patients experienced minor episodic discomfort over the joint that did not interfere with their job and daily activities (**Fig. 8, b**).

There is a report of posterior reinforcement of the ligamentous structures with non-absorbable wire and suture [25] in 6 patients with good functional recovery and no postoperative complications. Mild pain persisted in two cases. SCJ dislocations can be surgically treated with wire diafixation of the articulation [26], however, it can be associated with a high risk of injury to major vascular structures behind the articulation.



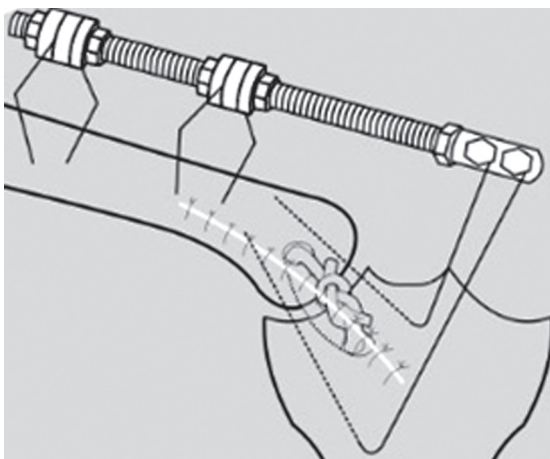
**Fig. 8** Figure-of-eight configuration of sternal cable with an atraumatic needle passing through the clavicle and manubrium (a); stable fixation of the SCJ provided (b) [24]

Orthopaedic and trauma surgeons of the Russian Ilizarov Scientific Centre “Restorative Traumatology and Orthopaedics [27] devised external fixation for SCJ disruptions using mylar bands to suture the articulation and wires to diafix the bone at an angle of 10–15° to the manubrium. Wires are bent and attached to a threaded rod using washers slotted and nuts. The SCJ wires are attached to the end of the threaded rod. Postoperatively, patients are recommended to use a sling for 3 to 4 weeks until the hardware is removed (**Fig. 9**). This technology was applied in treatment of 23 patients with dislocation of the sternal portion of the clavicle. There were 19 males and 4 females aged from 17 to 36 years. The period of inpatient stay was  $5.7 \pm 0.4$ , external fixation  $24.2 \pm 3.7$  and disability  $43.3 \pm 4.3$  days. The patients showed good anatomical and functional recovery.



**Fig. 9** Fixation of the SCJ with mylar band and wires at an angle of 10–15° to the manubrium

**SCJ reconstruction with synthetic materials and suture anchors.** Suture anchor repair of SCJ instability was described by Z. Abiddin et al [28] in 2006 in a series of 7 patients (1 bilateral). One case presented with posterior dislocation of the SCJ, and the remainder had anterior dislocations. Two Mitek Super Anchors (Johnson & Johnson Ltd, Edinburgh, UK) were used to obtain anchorage onto the manubrium (**Fig. 10**).



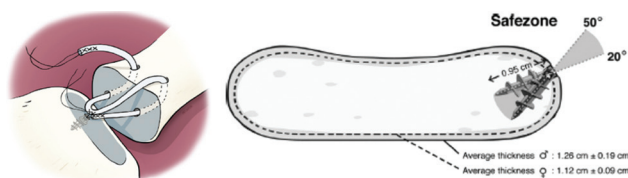
**Fig. 10** Suture anchors for treatment of sternoclavicular joint instability [28]

The anchors were placed near the edge of the manubrium. Two drill holes were then made at the medial end of the clavicle to facilitate the passage of transosseous nonabsorbable sutures. The articular surface of the clavicle was avoided. The postoperative management was to immobilize the arm in a sling for 2 weeks, followed by gradual mobilisation of the shoulder. Strenuous physical activities were avoided for a period of 4 months. The results were analysed by use of subjective (Oxford Shoulder Questionnaire) and objective (Constant score) criteria. The Oxford Questionnaire took into account the subjective assessment including activities of daily living and the amount of pain.

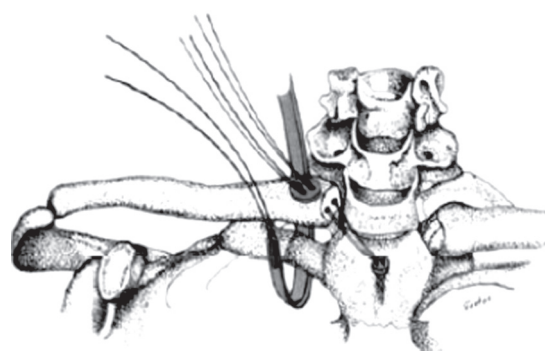
The functional outcome was evaluated by use of the Constant and Murley scoring system which incorporates various individual parameters including pain, activities of daily living, range of motion and power. The only poor result was in a man who had multiple rib fractures along with a fracture of the sternum and dislocation of the SCJ. He underwent revision of the stabilisation procedure one year after initial procedure for persistent pain. His initial outcome was satisfactory for 3 years after the revision surgery, but his symptoms of pain and instability recurred, and finally, an excision of the medial end of the clavicle was performed. One patient with bilateral SCJ dislocations fell off a horse 6 weeks after the stabilisation procedure. Another stabilisation procedure was successful on both sides, and the final result was satisfactory. All patients except one with the excised medial end of the clavicle went back to their previous employment.

In 2010 Lehmann et al [29] reported a case of surgical treatment of SCJ dislocation using a PDS cord around the clavicle and the first rib to stabilize the clavicle and a suture anchor placed into the manubrium for fixation to the medial side (**Fig. 11**). The patient used a brace for 4 weeks after the procedure and regained the mobility after 8 weeks. In 2014 Klaus Bak et al [30] described a series of 27 patients with anterior SVJ dislocation treated with a suture anchor and autologous tendon graft. A palmaris longus was used in 6 cases and a gracilis tendon autograft was used in 21 patients. The authors offered a safe zone for the placement of suture anchor into the lateral portion of the manubrium. Frontal plane with anchor placed, anchor's length and mean

breadth of the manubrium in males and females are shown in **Figure 12** according to Selthofer [31]. One tail of the graft is sutured with the first pair of sutures and passes medial to lateral through the hole drilled in the medial portion of the clavicle and is sutured in the SCJ close to the anchor with another pair of sutures, passes through the superior hole medial to lateral, and a free tail of the graft is sutured with the second pair of anchor sutures. Results of treatment showed the total WOSI score being improved from a median of 44 % (range, 6-62 %) preoperatively to 75 % (range, 13-93 %) at follow-up. Nine patients had 85 % of WOSI score. Three patients (12.5 %) underwent revision procedures. One patient developed redislocation by weight-lifting in supine position 2 weeks after the procedure and a surgery was performed for him with a good outcome. Another patient complained of a regular pain 6 months after the procedure and synovectomy performed for him resulted in pain relief. One more patient reported instability of the SCJ caused by inadequately sutured graft detected at revision procedure that was re-sutured in the functional manner. After the operation, 17 of 25 patients complained of donor site morbidity, and 10 still had some discomfort at follow-up. No infection or local vascular complications occurred.



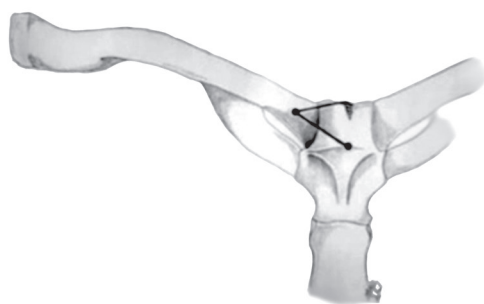
**Fig. 11** Fixation to the medial side using suture anchor placed into the manubrium and PSD cord around the clavicle and the first rib [31]



**Fig. 12** A safe zone identified to place a suture anchor into the lateral portion of the manubrium [29]

O'Reilly-Harbridge et al. described three-point suture anchor repair of traumatic SCJ dislocations (**Fig. 13**). The review identified 7 patients with posterior dislocations and one case of anterior dislocation surgically treated between 2005 and 2011 and followed up from 3 to 18 months. The surgical technique includes placement of anchors into the sternal notch in cranio-caudal direction, into the manubrium in anterior-to-posterior direction and into the medial clavicle [32]. The sutures are tied together to construct a triangular shape reconstruction in front of the SCJ. All patients were clinically assessed as capable to return to premorbid physical activities and work. The routine follow-up showed no issues documented with regard to chronic pain or ROM limitations.

Wallace et al [33] reported a new technique of stabilising the SC joint by reconstructing the costoclavicular ligament using a braided polyester mesh device (Surgilig Lockdown) (**Fig. 14**). This technique recreates the costoclavicular ligament and also stabilises the anterior and the posterior capsule during stabilisation. Their results showed no major or life threatening complication and all patients achieved good functional outcome and patient satisfaction.



**Fig. 13** Three-point suture anchor repair [32]



**Fig. 14** Surgilig lockdown device [33]





## CONCLUSION

There are several operative techniques used for disruptions of the SCJ but no gold standard has been defined. Each of the above methods has strengths and weaknesses, and individual and reasonable approach is essential in the choice of surgical procedure.

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