

Figure of Eight FiberTape Stabilization for Acute Posterior Sternoclavicular Joint Dislocation

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SUMMARY

Background. Acute posterior sternoclavicular joint dislocation is a rare, serious and difficult injury to diagnose and treat. Posteriorly dislocated clavicle may compress mediastinal structures making this injury an emergency requiring urgent reduction. There is no gold standard of treatment.

The purpose of this retrospective study is to demonstrate the treatment of acute posterior sternoclavicular joint dislocation with figure-of-eight FiberTape technique, its efficacy and mid-term outcomes.

Materials and methods. For this retrospective study, we recruited five patients who were treated for acute traumatic posterior sternoclavicular joint dislocation. Attempts of close reduction were unsuccessful in all cases. Open reduction and surgical fixation were therefore performed with figure-of-eight technique using FiberTape. Data concerning time from injury to surgical treatment, hospital stay time, preinjury sport activity level were analyzed. The median follow-up time was 12 months (range 10-26) which included clinical evaluations and the DASH and Oxford Shoulder score questionnaires.

Results. Open reduction and sternoclavicular joint fixation were successful in all subjects with no complications. The treatment functional results were very good. DASH scores were 0.8 (n = 2), 1.7, 2.5 and 3.3 and Oxford Shoulder scores 44, 44, 46, 46, 48. The durability of our fixation was confirmed when one of the patients had a subsequent bike accident 3 months after the procedure. The initial fixation was unaffected.

Conclusions. The presented technique allowed safe, effective, and durable results of the posterior sternoclavicular joint dislocations management.

KEY WORDS

Acute posterior sternoclavicular joint dislocation; FiberTape; open reduction and internal fixation; sternoclavicular injury; sternoclavicular reconstruction.

INTRODUCTION

The sternoclavicular joint (SCJ) is a saddle joint that makes the only true articulation between the upper limbs and the axial skeleton. SC joint lacks bone stability relying mostly on ligaments and capsule. The extrinsic structures such as the interclavicular ligament, costoclavicular ligament (CC), strong joint capsule and intraarticular disc ensure the stability and enable the clavicle to move. The injuries to the proximal clavicle are rare and the dislocations in this region are even more uncommon. The SCJ dislocation represent only 1% of all joints dislocations and about 3% of all upper limb dislocations (1). There are two main types of acute SCJ dislocation, anterior and posterior. Anterior dislocations are about nine times more common (2). They are less dangerous, mainly treated conservatively with good clinical outcomes (3). Posterior sternoclavicular joint dislocations (PSCJD) are, on the other hand, associated with serious life threatening conditions due to the mediastinal compression (4). The diagnosis of PSCJD can be difficult, as standard X-ray projections can many times mislead the clinician and posterior dislocation can be omitted. Serendipity X-ray projection in 40-degree cephalic tilt might be used, but if there is a high suspicion of PSCJD, CT scan is required for a proper evaluation (5). There is no specific PSCJD classification. Allman proposed SC injury classification. Complete ligamentous rupture with joint dislocation is grade III injury. Jaggard *et al.* introduced their classification proposal, making PSCJD type V sternoclavicular joint injury (6).

The PSCJD management is aimed at releasing the pressure of mediastinal structures by reduction of the dislocation. Closed reduction should be tried first at the emergency department. If it fails, reduction under general anesthesia should be performed. If closed reduction is not achievable, open reduction should be done. The operation should be performed in a multidisciplinary hospital with a thoracic surgeon back up (5).

During surgical intervention of acute dislocation soft tissue status, including intraarticular disc and joint capsule should be inspected. In case of major damage, joint should be stabilized (7). There are numerous techniques of reduction maneuvers and internal fixation methods (7-12). They are mainly described for chronic anterior dislocation, not for acute posterior. There is a limited literature about the condition involving big patient groups, therefore there isn't a gold standard of fixation. Metal implant-based methods, reconstructive graft techniques and artificial suture materials are used. To our best knowledge there are no publications reporting usage of FiberTape in this condition.

In this study we present 5 cases of acute posterior SCJ dislocation treated surgically with figure-of-eight Fiber-

Tape technique. We demonstrate our operation technique, patient outcome scores and mid-term follow-up results.

Aim of the study

The aim of this retrospective study is to demonstrate the treatment of acute posterior sternoclavicular joint dislocation with figure-of-eight FiberTape technique, its efficacy and mid-term outcomes.

MATERIALS AND METHODS

We reviewed five subjects for our study. They all sustained PSCJD and were treated in years between 2018 and 2020. Upon admission all patients underwent a detailed assessment, general medical history was taken, trauma mechanism and preinjury sport activity level were obtained. A meticulous physical examination was performed. Standard X-rays and CT scans were done before the procedure. All significant patient data (date of surgery, operated side, dominant hand side, hospital stay duration, complications) were gained retrospectively from medical records. All operations were carried out by single senior orthopedic surgeon. On follow-up visits all patients were informed about the study and agreed on publication of their anonymized photos and functional outcomes by signing an appropriate consents. The end-point of this study was a follow-up examination 10-26 months after surgery. Patients were asked to complete a DASH (disability of the arm, shoulder, and hand) and Oxford Shoulder score questionnaires.

Ethics

Bioethical committee approval was not required as the study is retrospective, and data analysed was concerning patients already operated.

Surgical technique and postoperative treatment

Failed closed reduction was an indication for an open procedure. All operations were performed under general anesthesia. Patients were positioned in the beach chair position. To facilitate easier reduction a gel pillow was put under patient's back between the scapulae. The patients were given muscle relaxant medications and a subsequent attempt of close reduction was performed. Traction of abducted upper limb was applied, then sterile tower clip was introduced to grasp the medial clavicle and direct forward traction was applied. Failed closed reduction in all 5 cases was an indication for the open procedure. A "L-shaped" incision of approximately 10 cm length (range from 7-11 cm) was made at the level of medial clavicle and sternal manubrium. The SC joint posterior dislocation was visually confirmed. Reduction was performed with help of pointed reduction clamps. A direct

force to proximal end of the clavicle was applied. Proper reduction was confirmed using intraoperative fluoroscopy. Intraoperatively posterior capsule, intraarticular disc and ligaments were inspected, when seriously damaged, stabilization was indicated. To achieve fixation four 2.5 mm holes were drilled bicortically, two in medial end of clavicle and two in sternal manubrium. Fixation was performed using a figure-of-eight technique with a FiberTape suture (Arthrex, Naples, Florida). A detailed suture technique is shown in **figure 1**.

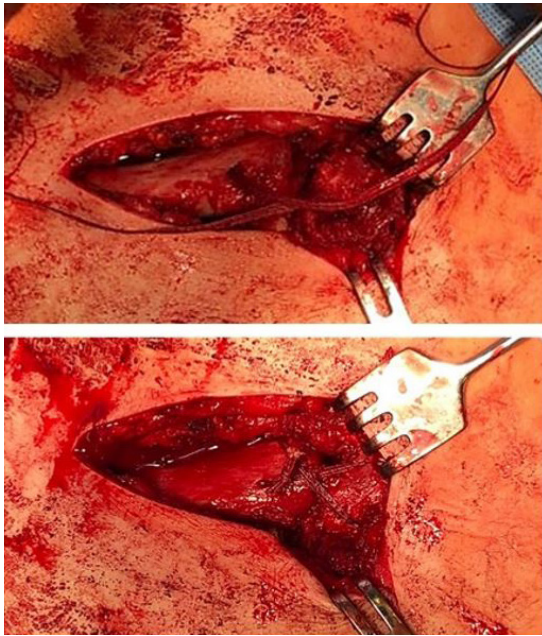


Figure 1. Surgical technique.

Postoperatively, patient's upper limb was immobilized in Dessault's sling for first 6 weeks. The time in the orthosis was intended to enable good ligamentous and soft tissue healing. Patients were instructed basic shoulder Codman Pendulum exercises. Moreover elbow, wrist and hand movements were encouraged. After 6 weeks sling was withdrawn,

and conventional physiotherapy was started to regain full range of motion. Full active range of motion exercises and weight bearing were gradually allowed, according to clinical course. All patients completed a rehabilitation program with a physiotherapist. Patients were allowed to return to sport after minimum of 12 weeks after surgery.

The follow-up visits were performed at 6, 12 weeks and 10-12 months after operation, in accordance with existing standard trauma visits protocol. A detailed orthopedic examination was performed on each visit. At the last follow-up visit patients were asked to complete patient specific functional scale questionnaires.

RESULTS

Five patients suffered from PSCJD and underwent open reposition with figure-of-eight FiberTape fixation technique. Their main characteristics, age, gender, injury mechanism and concomitant injuries are shown in the **table I**.

All 5 patients presented with an acute injury, type III Allman (13) type V Jaggard (6). Three of them were referred to our center from smaller regional hospitals as they did not have a cardiothoracic surgeon back up. Two patients presented to the emergency department in our Center. All subjects experienced a bicycle accident. The main symptoms were pain in SCJ region. Patient 3 felt short of breath with normal blood saturation level. Patient 2 experienced pain on swallowing. None of the patients experienced other injuries. All patients were hemodynamically stable. None of the patients had signs of neurovascular structure damage. Therefore, none of the surgeries were urgent and could be properly planned for subsequent days. Patient 2 CT-scan is shown in **figure 2**. In all cases a primary closed reduction attempt was performed, without success. All 5 subjects were therefore qualified for reduction under general anesthesia. All dislocations were irreducible and open reduction was indicated and performed. In all cases joint capsule, intraarticular disc and ligaments were seriously damaged, making indication for stabilization (7).

Table I. General information.

Patient	Sex	Age	Side	Patient's dominant hand	Preinjury occupation and sport activity	Time from injury to surgery in days	Follow-up time in months
1	M	19	Left	Right	Student/minor physical activity	2	11
2	M	20	Right	Right	Student/Krav Mag competitor	2	12
3	F	41	Left	Right	Nurse/minor physical activity	1	10
4	M	43	Left	Right	Office worker/non-professional bike	5	24
5	M	27	Left	Right	Office worker/minor physical activity	7	26

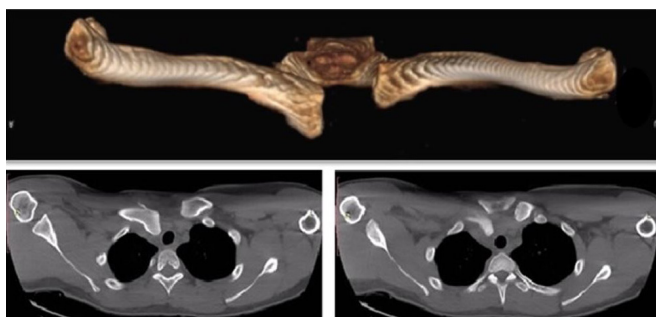


Figure 2. Patient 2 CT.

The median time from injury to operation was 2 days (range from 1 to 7). Median time of operation was 55 min (range from 42 to 70 min). There were no intraoperative complications. A thoracic surgeon was present in the operation theatre but was not asked for assistance. Blood loss was neglectable. The median hospital stay was 5 days (range from 4 to 7).

All compression symptoms in Patient 2 and 3 resigned after operation.

At the early follow-up visits (6, 12 weeks) no wound or neurovascular complications were observed.

Patient 1 experienced a second bicycle accident 3 months after procedure. He showed up at our hospital ED with shoulder pain. A physical examination, X-ray and CT scan were performed. Upon examination SCJ was stable. A CT scan confirmed proper clavicle position, without loosening of the fixation material. No injuries to SCJ region or shoulder region were observed. He was diagnosed with shoulder contusion and discharged with upper limb sparing recommendations.

At one year follow-up visit all patients reached pre-injury physical activity levels. The median DASH and Oxford scores were 1.7 and Oxford Shoulder score was 46. Detailed scores are presented in the **table II**.

There was no instability observed. All patients had a full range of motion of the upper extremity, the average shoulder abduction, forward elevation, external rotation in 90

Table II. Patient specific scales 12-months results.

Patient	DASH score	Oxford Shoulder score
1	0.8	46
2	0.8	46
3	2.5	44
4	3.3	44
5	1.7	48

degrees of abduction, and external rotation in adduction were $170^\circ \pm 15^\circ$, $165^\circ \pm 20^\circ$, $80^\circ \pm 15^\circ$, and $65^\circ \pm 25^\circ$, respectively. Patient 2 1-year range of motion is shown in **figure 3**.

Three of 5 patients reported some residual tenderness at the SCJ. Two patients experienced a minor deformity in the SCJ region without clinical significance. No patients reported any residual instability of the SCJ.

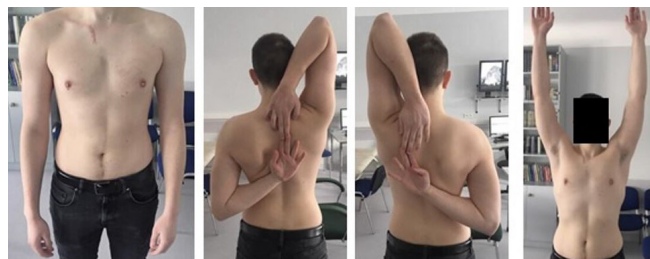


Figure 3. Patient 2 1-year functional outcomes/range of motion.

DISCUSSION

PSCJD is a rare, difficult to diagnose and dangerous condition. In our Clinic, a major trauma center for a whole region, we observed only 5 cases of PSCJD which we describe in this study. In the literature only around 120 cases have been reported (5). What is more, patients can be easily misdiagnosed, as standard X-ray projections may be misleading and posterior dislocation can be omitted (5). Therefore, in all our patients, when PSCJD was suspected, a CT scan was performed for a proper evaluation. The severity of the condition is described in many papers. Worman and Leagus reported that 16 of 60 patients had suffered complications involving the trachea, esophagus, or great vessel compression (14). Mark Fenig *et al.* reported a fatal case of brachiocephalic vein laceration in a 16-year-old boy (15). Therefore, any suspicion of posterior dislocation should be treated seriously, as an emergency. It is reported that about 60% of PSCJD are successfully treated by close reduction (6). In all our patients several attempts of close reduction were performed by many doctors. They were all unsuccessful. There is limited literature on the condition, involving a sufficient number of patients. There is no consensus, whether surgically reduced dislocation should be anyhow stabilized. Kendal *et al.* in their systematic review of PSCJD recommend that in select acute cases with substantial ligament disruption, ligament reconstruction with Figure-of-eight autograft or augmentation of synthetic material is indicated (7). We believe that a thorough examination and inspection of capsule and intraarticular disc should be performed and based on damage severity the stabilization should be indicated. In all our cases the intraarticular disc was ruptured

and surrounding tissues including joint capsule were seriously damaged.

There is no gold standard of fixation. We came across many fixation methods of sternoclavicular joint instability. They were mainly described for chronic anterior dislocation. The first was based on a metal implant (K-wires or plates) (16). K-wires stabilization was widely used in the past, but many serious complications have been reported. Lyons and Rockwood reported six major vascular injuries and eight deaths due to pin migration from SCJ (17). Janssens de Varebeke *et al.* reported the pulmonary artery main trunk perforation by Kirshner wire migration from right sternoclavicular joint (18). Therefore K-wires are now not recommended to use in SCJ region (16). Locking plate usage was described by Rongguang *et al.* in a case series of 5 patients with SCJ dislocation (16). They have shown good results in all patients, but all subjects had a subsequent operation for plate removal (17). We believe it is fundamental to consider the range of motion of the clavicle in the sternoclavicular joint. For every 10 degrees of forward flexion of the glenohumeral joint clavicle elevates about 4 degrees. Moreover, any complex movement of the upper extremity engages the sternoclavicular joint. The clavicle may rotate up to 40° along its longitudinal axis (19). These movements make rigid metal implants susceptible to migration and failure. In our clinical experience we observed plate failure after proximal clavicle fracture fixation, what is consistent with literature (8). Therefore, reconstructive techniques using grafts were introduced. Many grafting materials are described: semitendinosus, palmaris, plantaris, sternocleidomastoid, gracilis tendons or synthetic FiberWire or Rota-Lok (9, 12, 20). Moreover, many techniques have been reported, single loop (9), double figure-of-eight (11) or unicortical (21) reconstructions. Spencer and Kuhn compared 3 fixation techniques on cadaveric specimens. Figure-of-eight semitendinosus reconstruction was reported to have superior biomechanical properties (21). The downsides of all grafts are possible atrophy or elongation in time, causing lack of stability and recurrent instability (21). Moreover, the need of graft harvesting extends the operation to distant regions.

Taking into account all methods described above, we decided to stabilize SCJ with synthetic heavy suture FiberTape material. To our best knowledge there are no publications reporting usage of this material in this condition.

In all patients, we used FiberTape figure-of-eight fixation technique. We observed that this material and method offers a perfect combination of strength and flexibility of fixation. It provides a good replacement for the damaged joint stabilizing tissues, enabling their regeneration. Moreover, it does not use any autografts eliminating graft

harvesting procedure and all downsides of it. Figure-of-8 technique enables movement in the joint, not limiting the upper extremity range of motion. We believe that bicortical drilling and fixation method enables proper stability, both posterior and anterior.

What is worth mentioning, is that Patient 1 experienced a second bicycle accident, falling on the shoulder and SCJ region. It did not cause any damage to the joint or fixation. This proves the durability of heavy suture tape and our technique.

The main limitations of our study are the small sample size, its retrospective character, lack of randomization and control group. All this is due to the rarity of the condition and need for open fixation. For proper evaluation of long-term results and incidents of joint arthrosis further investigations with large patients groups and randomization are needed.

CONCLUSIONS

The figure-of-eight FiberTape technique has proved to be safe and enabled good stability of SCJ. The midterm outcomes in all our patients were good. There were no major complications observed. Patient satisfaction with the treatment was high, all patients returned to the same physical activity level as preinjury. The durability of fixation was confirmed by a subsequent bicycle accident of one of the patients.

FUNDINGS

None.

DATA AVAILABILITY

Data are available under reasonable request to the corresponding author.

CONTRIBUTIONS

PN: literature search, study design, data collection, analysis and interpretation, writing. PC: conceptualization, data interpretation, critical revision. DL: data analysis and interpretation. KB, PP: data analysis and interpretation, critical revision. PW: data interpretation, critical revision. KK: conceptualization, data analysis and interpretation, critical revision. All authors read and approved the final manuscript.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

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