Surgical Technique

Results of Stabilization of Sternoclavicular Joint Luxations Using a Polydioxanone Envelope Plasty

Jean W. M. Gardeniers MD, PhD, Jan Burgemeester MD,
Jaap Luttjeboer MD, Wim H. C. Rijnen MD, PhD

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Abstract

Background Surgical treatment options for sternoclavicular joint luxations described in the literature are numerous, although all have limitations. Therefore, there is no favorable surgical treatment for sternoclavicular luxations when nonoperative treatment has failed.

Description of Technique We developed the polydioxanone (PDS) envelope plasty, a modification of the figure-of-eight technique, using a PDS ligament.

Methods We retrospectively reviewed 39 patients (40 joints), treated with a PDS envelope plasty for invalidating sternoclavicular luxations. The minimum followup was 10 months (average, 52 months; range, 10–171 months). The Simple Shoulder Test (SST), Constant-Murley shoulder

score, and subjective categorical results were recorded preoperatively and postoperatively.

Results In most patients, postoperative functional shoulder scores were excellent (mean Constant-Murley score, 90, range, 52–100; mean SST, 10; range, 2–12). Ninety percent of patients had an improvement of shoulder function at followup. Only minor complications occurred. Thirteen percent of patients had spontaneous postoperative subluxations. However, the postoperative shoulder function improved in all these patients.

Conclusions The PDS envelope plasty is a simple procedure, a modification of the best-reported technique. We have promising results with high shoulder scores.

Level of Evidence Level IV, therapeutic study. See Guidelines for Authors for a complete description of levels of evidence.

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Each author certifies that his or her institution approved or waived approval for the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.

J. W. M. Gardeniers (✉), J. Burgemeester, J. Luttjeboer,
W. H. C. Rijnen

Department of Orthopaedics, 667, Radboud University
Nijmegen Medical Center, PO Box 9101,
6500 HB Nijmegen, The Netherlands
e-mail: j.gardeniers@orthop.umcn.nl;
jeanwmgardeniers@me.com

Introduction

Sternoclavicular luxations occur rarely, accounting for 3% of all shoulder girdle injuries. These luxations are caused mainly by trauma, mostly car accidents and sporting accidents [5, 10, 20]. Nontraumatic luxations also occur, caused by hypoplasia or aplasia of the articular disc, a hyperlax joint capsule, or an enlarged angle between the joint surface and sternum [16, 19]. In most cases of acute joint dislocation, the joint can be stabilized by closed reduction. Unfortunately, nonoperative treatment is not satisfying in all cases, failing in 25% to 31% of patients [7, 11, 12]. Recurrent dislocations with pain and discomfort can cause a feeling of instability in the upper extremity, cosmetic asymmetry, progressive deformity, periarticular calcifications, and osteoarthritis. Posterior dislocations may cause dyspnea, dysphagia, cyanosis, and compression of

major vessels [9, 13, 15, 20]. Open reduction should be considered when closed reduction and nonoperative treatment have failed. Indications for open reduction are recurrent posterior luxations and anterior luxations with pain, discomfort, and persistent instability [12, 13, 15, 17]. Habitual luxations, caused by general hyperlaxity, should be distinguished from luxations caused by previous trauma and should be treated nonoperatively [16, 18].

There are numerous treatment options described in the literature [1–4, 7, 9, 10, 12, 13, 17, 18, 23], but studies reporting the results of different techniques are few and mostly outdated [1, 3, 4, 9, 12, 17]. Therefore, there is no favorable surgical treatment for sternoclavicular luxations when nonoperative treatment has failed. A systematic review by Glass et al. [12], including 251 patients in 24 case series, concluded tenodesis, suture fixation, and open reduction and internal fixation have better results than medial clavicle resection and tendon graft. Another systematic review by Thut et al. [24] assessing clinical and biomechanical studies recommended the use of tendon graft in a figure-of-eight fashion through drill holes in the sternum and clavicle. Spencer and Kuhn [21] reported a figure-of-eight tendon reconstruction has greater strength and stiffness than intramedullary tendon and subclavius reconstructions performed in a cadaver study.

A limitation with designing a reliable surgical technique is the complications related to the anatomic location of the joint. The use of metal wires is not recommended because these materials can migrate to the heart, lungs, and major vessels with disastrous results [11, 15, 20, 26]. Plates and screws are not designed to bridge a joint immediately under the skin; owing to immobility, they may break, irritate the skin, and need to be removed [10, 12, 15]. The disadvantages of suture materials are the time-dependent limitations of strength and durability [1, 15, 23]. Tendon and fascia autografts have fewer complications but cause donor site morbidity [3, 12, 15, 19]. The last option, a medial clavicle resection, may cause recurrent pain, instability, and cosmetic problems. The indication is only as a last resort for patients with osteoarthritis [2, 12, 18, 24].

In this study, we describe a technique we developed called polydioxanone (PDS) envelope plasty, a modification of the figure-of-eight technique, using a PDS ligament. We then determined whether we could restore and maintain normal (1) shoulder function and (2) shoulder stability and (3) prevent or minimize complications using our technique.

Surgical Technique

With the patient under general anesthesia, in a supine beach chair position, and after sterile draping, an incision was made from midsternum to the medial $\frac{1}{3}$ of the

Fig. 1 An operative photograph shows the sternal and clavicular parts of the joint and in between the disc.

clavicle. Subperiosteally, the medial $\frac{1}{3}$ of the clavicle was exposed and the sternoclavicular joint identified. The pectoralis muscle was elevated from the sternum. The sternoclavicular joint capsule was opened and stay sutures were applied in the cranial and caudal capsule flaps. The cartilaginous disc was identified and two stay sutures were passed through the disc (Fig. 1). Osteophytes, calcifications, and scar tissue were removed. The joint was reduced using a forceps. Using a 3.2-mm drill bit, an inferior-to-superior drill hole was made through the clavicle, approximately 1 cm lateral from the sternoclavicular joint and widened to 4.5 mm. Two 2-0 Vicryl® sutures (Ethicon, Inc, Somerville, NJ, USA) were passed through the drill hole. Next, a 4.5-mm tunnel was made in the sternum connecting two 4.5-mm drill holes in the outer cortex with a curved forceps, and two Vicryl® sutures were passed through the tunnel (Fig. 2A). A 300-mm-long and 5-mm-wide PDS ligament (Ethicon, Inc) was attached to the caudal end of one of the Vicryl® sutures and passed through the clavicle, crossing the joint, and passed through the hole in the sternum (Fig. 2B). The ligament was crossed back as a figure eight to the clavicle, brought under manual tension, and all edges and crossings were sutured to one another using two 2-0 Vicryl® sutures. The long end of the ligament was passed again in a cranial direction through the hole using the second Vicryl® suture (Fig. 2C). Subsequently, it was passed posterior to the interclavicular ligament to the sternum and through the sternal tunnel, in a caudal direction and then finally back to the clavicle (Fig. 2D). Tension was applied, and all corners and crossings were sutured (Fig. 3). The capsule was closed and the stay sutures of the disc were passed through the capsular flaps and tied over the capsule, elevating the disc. Finally, the muscle was reattached and the wound closed using a 4-0 Monocryl® skin suture (Ethicon, Inc).

Fig. 2A–D (A) The anatomy of the sternoclavicular joint is illustrated with both drill holes and four Vicryl® sutures in place. CCL = costoclavicular ligament; ASCL = anterior sternoclavicular ligament; IC = interclavicular; AD = articular disc. (B) The PDS ligament is passed through the clavicle and sternal hole using the Vicryl® sutures. (C) The PDS ligament crosses back over the joint and passes through the sternal hole again, creating a figure-of-eight. (D) The envelope plasty is completed by passing the PDS ligament distally from the sternum to the clavicle and proximally from the clavicle under the interclavicular ligament and then back to the sternum.

Fig. 3 An operative photograph shows how the PDS ligament is passed as a figure-of-eight through drill holes in the medial clavicle and sternum.

Average surgical time was 1 hour and 15 minutes with minimal blood loss.

Immediately postoperatively, the patient's arm was placed in a shoulder immobilizer for 6 weeks. Only 30° rotational exercises in 0° abduction and flexion were allowed. After 6 weeks, passive exercises in 90° abduction

and flexion were allowed, and after 12 weeks, full ROM was allowed under the guidance of a physiotherapist. Full sporting activities were restricted until 6 months after surgery.

Patients and Methods

We retrospectively reviewed 39 patients (40 joints) treated for sternoclavicular luxations, operated on between 1992 and 2010 in the Radboud University Nijmegen Medical Center. All operations were performed by one surgeon (JWMG). Indications for treatment were invalidating, painful sternoclavicular luxations after failure of nonoperative treatment. Patients with Ehler-Danlos or Marfan syndrome were excluded from surgery. All patients between 13 and 55 years old meeting the indications for treatment were included. One patient who was not treated with a standard PDS envelope plasty was excluded. No patient was lost to followup. The minimum followup was 10 months (mean, 52 months; range, 10–171 months).

We treated 15 male and 24 female patients with an average age of 26 years (range, 13–55 years). Thirty-four patients (35 joints) had an anterior sternoclavicular luxation, and five had a posterior luxation. One patient had bilateral surgery. In 24 patients (25 joints), the luxations were caused by trauma and 15 patients had repeated painful luxations without history of trauma. Most traumatic luxations were caused by sport ($n = 11$) or traffic accidents ($n = 8$). One patient underwent a previous palmaris longus plasty in another hospital, and one patient had previous

K-wire fixation in another hospital, resulting in perforation of the pulmonary artery and an emergency thoracotomy.

The Constant-Murley shoulder test [6], Simple Shoulder Test (SST) [25], and subjective categorical results (excellent/good/fair/poor) were recorded. During followup, the same scores were recorded in December 2005 for patients treated between 1992 and 2004 and in November 2011 for patients treated between 2005 and 2010. Patients without complaints were discharged 3 years postoperatively. Patients who were discharged were recalled to our outpatient department for followup. Whenever this was not possible, the patients were interviewed via telephone and they completed the Constant-Murley and SST scores at home. All patients were asked specifically to provide subjective remarks.

Results

Mean Constant-Murley and SST scores improved after surgery. The Constant-Murley score improved 30 points, from 61 preoperatively (range, 21–100) to 90 (range, 52–100) at followup. Thirty-five patients had higher postoperative Constant-Murley scores, one had a higher score on one side and an equal score on the other side, and three had lower postoperative scores. Two of these three patients had resubluxation and one patient had a subacromial impingement syndrome develop. The SST score increased 4.8 points (minimal clinical important difference, 2.1 [22]), from 5.2 (range, 0–12) preoperatively to 10 (range, 0–12) at followup (Table 1). Thirty-four patients had higher postoperative SST scores, one had a higher score on one side and an equal score on the other side, and four had equal SST scores preoperatively and postoperatively. Of these five joints with equal scores, two had maximal preoperative SST scores and two had recurrent subluxations during the followup period. Thirty patients (31 joints) had excellent or good subjective results, six had fair results, and three had poor results.

Eight patients had recurrent subluxations after surgery. In two patients, this was caused by trauma: one patient fell down the stairs and one experienced trauma during judo. In the other six patients, the recurrent subluxation occurred spontaneously. The patients with traumatic resubluxations underwent reoperation using the same technique. Two of six patients with spontaneous subluxations had reoperations because of persistent pain. This was performed using the same technique, and in one case, additional fixation of the clavicle to the first rib was performed with good results. All six patients with spontaneous resubluxations stated they experienced more stability, more power, nearly normal ROM, normal daily activities, and an increase in Constant-Murley and SST scores (Table 2).

Table 1. Preoperative and postoperative shoulder scores

Variable	All patients (n = 39)		Anterior (n = 34)		Posterior (n = 5)		Traumatic (n = 24)		Atraumatic (n = 5)	
	Constant-Murley score	SST	Constant-Murley score	SST	Constant-Murley score	SST	Constant-Murley score	SST	Constant-Murley score	SST
Preoperative score (points)*	61 (21–100)	5.2 (0–12)	60 (21–100)	5.3 (0–12)	64 (44–85)	4.6 (0–9)	63 (21–100)	5.7 (0–12)	57 (21–89)	4.4 (0–9)
Postoperative score (points)*	90 (52–100)	10 (2–12)	90 (52–100)	10 (2–12)	92 (70–100)	11 (8–12)	91 (52–110)	10 (7–12)	90 (57–100)	9.9 (2–12)
Difference in score (points)	30	4.9	30	4.7	28	6.4	28	4.3	33	5.5
Number of patients with an increased score	36 (92%)	35 (90%)	31 (91%)	30 (88%)	5 (100%)	5 (100%)	21 (88%)	20 (83%)	5 (100%)	5 (100%)
Number of patients with an equal score	0	4 (10%)	0	4 (12%)	0	0	0	4 (17%)	0	0
Number of patients with a decreased score	3 (7.7%)	0	3 (8.8%)	0	0	0	3 (13%)	0	0	0

* Values are expressed as mean, with range in parentheses; SST = Simple Shoulder Test.

Table 2. Postoperative subluxations

Variable	Total	Traumatic	Nontraumatic
Number of patients with subluxations	8	2	6
Time since surgery (months)*	58 (1–32)	18 (5–32)	3.5 (1–6)
Δ Constant-Murley (points) (number of increased scores)	19 (6)	20 (2)	19 (4)
Δ SST (points) (number of increased scores)	2.5 (6)	2 (2)	2.7 (4)
Reoperation (number of patients)	4	2	2
Subluxation after reoperation (number of patients)	1	1	0
No subluxation after reoperation (number of patients)	3	1	2

* Values are expressed as mean, with range in parentheses; SST = Simple Shoulder Test.

Four patients had keloids developed, which led to cosmetic problems. One patient had a postoperative low-grade infection that was treated nonoperatively and successfully and one had permanent swelling of the joint of unknown origin.

Discussion

Surgical treatment options for sternoclavicular joint luxations described in the literature are numerous, but all have limitations [1–4, 7, 9, 10, 12, 13, 17, 18, 23]. Therefore, no favorable surgical treatment exists for sternoclavicular luxations when nonoperative treatment has failed. In this study, we determined whether we could restore and maintain normal (1) shoulder function and (2) shoulder stability and (3) prevent or minimize complications using a new technique we developed called PDS envelope plasty, a modification of the figure-of-eight technique, using a PDS ligament. Mean Constant-Murley and SST scores increased and 90% of patients had better postoperative shoulder function. Only minor complications occurred. Thirteen percent of patients had spontaneous postoperative subluxations; however, these patients still had improvement in shoulder function.

A limitation of our study is the lack of a control group, which makes our results less comparable to results of other types of treatment. Despite the relatively large group in our study, it is still a limited number of patients, which is another limitation. Most patients were referred to our academic center because of recurrent painful luxations after 6 months to 3 years of failed nonoperative treatment. Although this group had a surgical indication, it caused a sampling bias. We also treated a mixed group of traumatic and nontraumatic luxations. We found no differences between the traumatic and nontraumatic cases; however, preoperatively it sometimes is difficult to distinguish habitual luxations caused by general hyperlaxity from recurrent luxations after minor trauma. Surgeons always should be cautious with habitual luxations. Patients with

acute dislocations have better functional outcomes than patients with chronic dislocations [12]. Because we did not register the duration of complaints, we cannot state whether there is any correlation between the duration of complaints and the functional outcome.

Comparison with other studies is difficult because of the limited number of studies available with comparable outcome measures. In a review by Glass et al. [12], of 251 patients treated with different methods, 80% of all patients and 82% of all patients who underwent surgery had fair or good results (Constant-Murley score > 80). In our study the Constant-Murley scores were higher than 80 in 87.5% of our patients. We found three comparable studies using tendon graft or suture materials. Abbidin et al. [1], describing the treatment of eight cases using suture anchors, reported a mean Constant-Murley score of 75 at followup. Armstrong and Dias [3] treated seven shoulders using the sternocleidomastoid tendon. One patient had postoperative shoulder impairment (14%). Bae et al. [4] treated nine chronic anterior luxations in children using tendon grafts, resulting in an average postoperative SST score of 11.4. These results are difficult to compare with our results because Bae et al. [4] operated on children and Armstrong and Dias [3] did not use comparable outcome measures. Glass et al. [12] and Abbidin et al. [1] reported Constant-Murley scores and had lower functional scores than we found in our study.

In total, eight patients in our study had subluxations during followup, six of them spontaneously. Although Constant-Murley, SST, and subjective scores were higher postoperatively, the rate of resubluxations is relatively high. It is difficult to compare with other studies as most do not describe postoperative subluxations, which is peculiar given our amount of subluxations and those of Armstrong and Dias [3], who reported subluxations in five of seven patients treated with a sternocleidomastoid tendon plasty. The resubluxations in our study developed after an average of 18 months (range, 5–32 months) postoperatively in the patients with spontaneous subluxations and after an average of 3.5 months (range, 1–6 months) postoperatively in the patients with postoperative trauma. The PDS ligament

half-time strength is 6 weeks [8]. The other patients with spontaneous postoperative subluxations likely had insufficient connective tissue to keep the sternoclavicular joint stable. One patient was diagnosed postoperatively with Ehlers-Danlos syndrome and should not have had the surgery. Patients with chronic luxations are reported to have a worse outcome owing to degeneration of the articular disc [12]. The fact that all our patients had chronic dislocations and were treated nonoperatively first, often more than a year, also may have played a role in the high number of postoperative subluxations. A standardized treatment protocol with earlier surgery after nonoperative treatment has failed might reduce this number.

Our patients had only minor complications: four patients had keloids, one had a low-grade infection, and one had a swollen joint. No subcutaneous materials were visible, no patients needed reoperations to remove materials, and no life-threatening complications occurred owing to migration of materials. Because we did not have to harvest any tendons, there was no donor site morbidity. No injury to mediastinal structures occurred because we did not perforate the dorsal cortex of the sternum. We had no complications using PDS ligaments and experience with PDS materials is extensive. In particular, there is much experience in reconstruction of the acromioclavicular joint, with good to excellent results in 90% of patients [14].

The PDS envelope reconstruction is a simple modified version of the best-reported technique without the reported disadvantages and complications. We have promising results with a high number of good shoulder scores. The high number of resubluxations might be reduced by prompt surgery after failed nonoperative treatment. We believe, if nonoperative treatment fails, patients should be undergo surgery as soon as possible because it might preserve the disc and prevent osteoarthritis owing to the recurrent luxations. Patients with hyperlaxity should in principle not undergo surgery or the patients must be informed that the technique does not create 100% stability; however, it does diminish complaints.

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