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Dorsal Claviculectomy For Treatment Of Brachial Plexus Injury After Scapulothoracic Fusion: A Case Report And Literature Review

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Learning Point of the Article:

Dorsal claviculectomy is a novel treatment for brachial plexus stretch injury following scapulothoracic fusion; early diagnosis and strategic interventions enhance patient outcomes.

Abstract

Introduction: Scapulothoracic fusion is a procedure used to treat severe cases of scapular instability, most commonly due to facioscapulohumeral dystrophy (FSHD). Patients who undergo scapulothoracic fusion surgery are at risk for neurovascular complications such as brachial plexus (BP) injury.

Case Report: A 35-year-old right-hand-dominant female with FSHD who underwent scapulothoracic fusion that was complicated by a BP injury, which did not improve with reoperation for scapular repositioning.

Conclusion: We performed a novel treatment of dorsal claviculectomy, after which the patient experienced near complete recovery of her BP injury. Dorsal claviculectomy can be considered as a treatment option for BP injury following scapulothoracic fusion to relieve BP stretch and promote neural recovery.

Keywords: Brachial plexus injury, dorsal claviculectomy, facioscapulohumeral dystrophy, neurovascular complications, scapular stabilization, scapulothoracic fusion, winged scapula.

Introduction

Scapulothoracic fusion is a procedure used to stabilize the scapula by fixating it to the chest wall. This procedure is used in conditions of severe scapular dysfunction, such as traumatic scapulothoracic dissociation, winged scapula from conditions such as facioscapulohumeral dystrophy (FSHD), and congenital deformities such as Sprengel's deformity, among other indications [1]. Scapulothoracic fusion is often a last resort, after patients have exhausted more conservative measures, such as physical therapy, bracing, injections, or tendon transfers [2]. Scapulothoracic fusion carries a number of risks, including pneumothorax, nonunion, rib fractures, and brachial plexus (BP) injuries [3]. BP injuries have been reported in 2.5–8.3% of cases of scapulothoracic fusion for FSHD [3, 4, 5].

The goal of scapulothoracic fusion is to improve shoulder stability or correct a deformity (depending on the indication) by fixating the scapula to the chest wall. The procedure carries certain risks, including failure to improve symptoms, failure to fuse, reduced shoulder mobility, pneumothorax, cosmetic issues, and neurovascular injury including BP injury [3]. We present a case report of a patient treated with pan BP injury following scapulothoracic fusion. The injury failed to improve with repositioning of the scapula and was treated using a novel approach: Dorsal claviculectomy. We also provide a review of the

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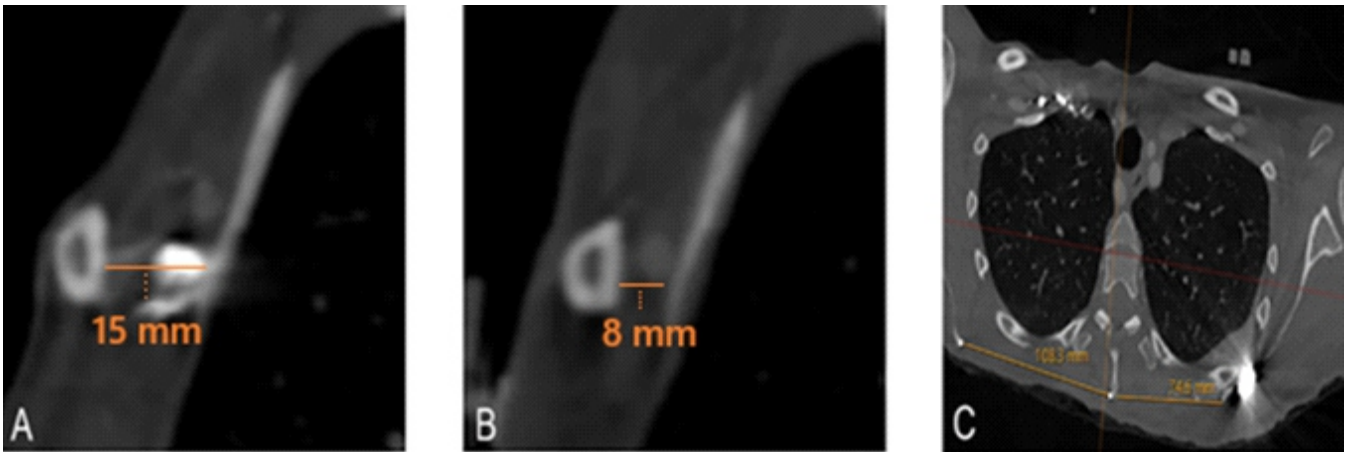

Figure 1: Computed tomography angiography imaging (a) of the chest showing the normal costoclavicular interval on the unaffected right side (15 mm), (b) narrowing on the affected left side (8 mm), and (c) medialization of the left scapula noted relative to the right side, as well as narrowing of the costoclavicular interval on the left side.

literature on BP injuries related to scapulothoracic fusion, as well as other previously described management strategies.

Case Report

A 35-year-old right-hand-dominant female presented as a new patient to our emergency department with a history of FSHD, with left scapular winging and progressive difficulty with shoulder abduction and forward flexion. She had undergone a long thoracic nerve decompression 2 years ago and a pectoralis major transfer 18 months prior, both at other hospitals, neither of which provided any significant benefit. These previous surgeries were complicated by postoperative venous thromboembolic disease.

She also underwent a scapulothoracic fusion at another hospital, 4 weeks before presentation, where the scapula was fixated to ribs three, four, five, and six. Intraoperative monitoring was utilized, and a decrease in somatosensory evoked potential to the left upper extremity (LUE) was noted at the beginning of the case, which remained stable and did not worsen. Postoperatively, she presented with a complete loss of motor function in her LUE, severe burning pain, as well as a near-complete loss of sensation. Bilateral radial pulses were noted to be intact. A computed tomography (CT) of venogram demonstrated large thrombus in the left subclavian vein and narrowing of the costoclavicular portion of the thoracic outlet. The patient was returned to the operating room 2 days postoperatively for repositioning of the scapula on the chest

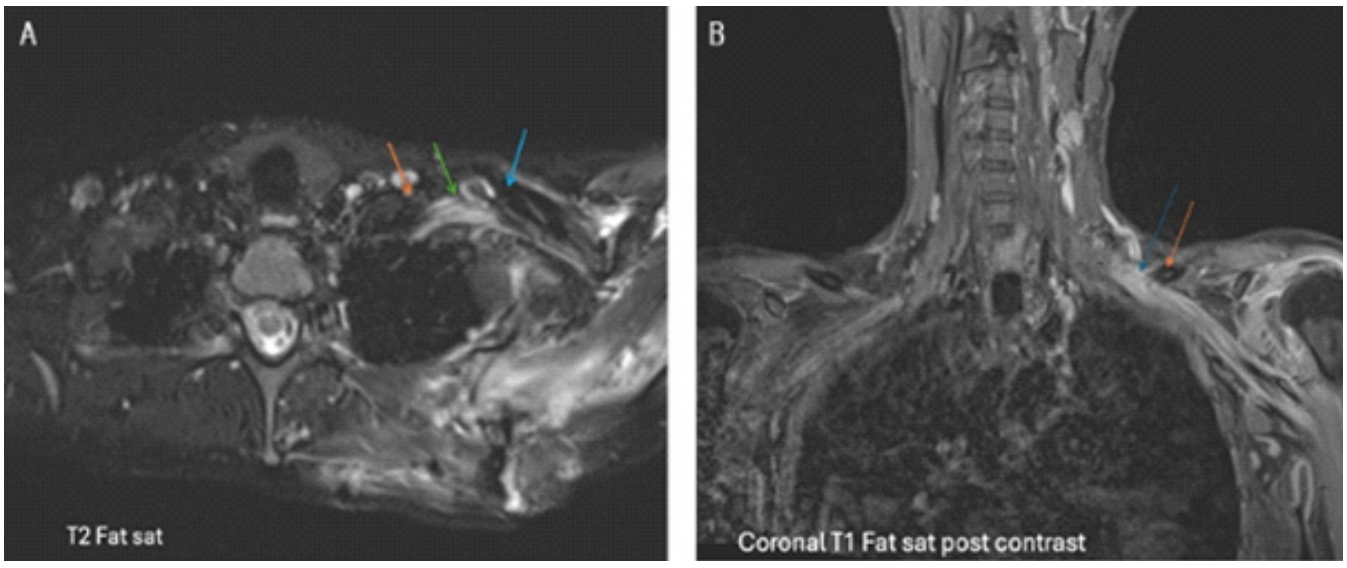

Figure 2: (a) Axial T2FS: Edematous and posteriorly angled left brachial plexus nerves (green arrow) coursing distally, inferior to the clavicle (blue arrow). Lateral interscalene area (orange arrow). (b) Coronal T1FS: Enhancement of the left brachial plexus (blue arrow), extending from proximal to the clavicle (orange arrow) distally.

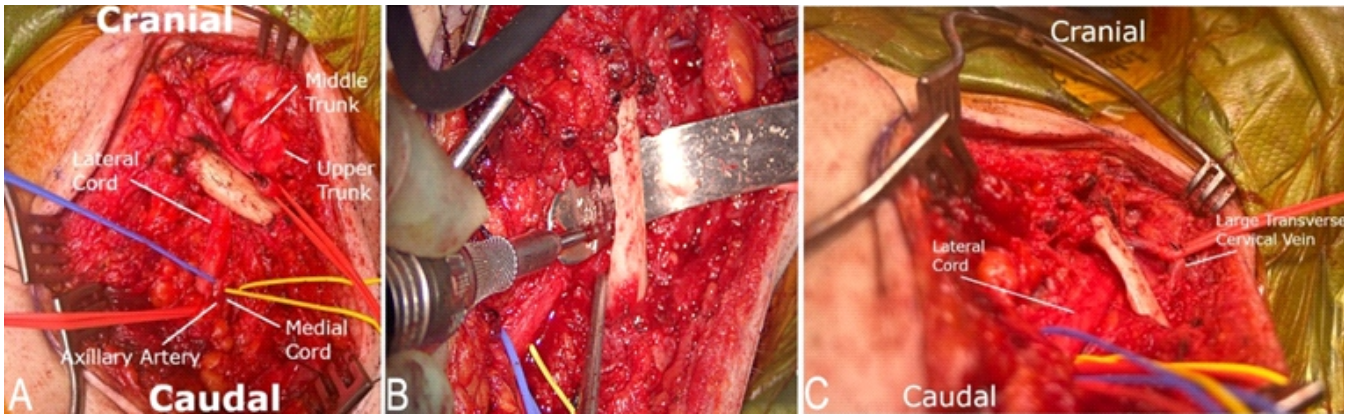

Figure 3: (a) Exposure of the supraclavicular and infraclavicular brachial plexus, with downward stretch of the brachial plexus by the clavicle. (b) High-speed drill used to perform dorsal claviculectomy, with a malleable retractor protecting the retroclavicular neurovascular elements. (c) Relief of the brachial plexus downward stretch following dorsal claviculectomy.

wall. The scapula was translated cranially and fixated to ribs two, three, four, and five to reduce compression within the thoracic outlet. Postoperatively, the patient had a persistent LUE flail arm with no improvement. Therapeutic anticoagulation was prescribed for the treatment of LUE deep vein thrombosis (LUE DVT).

Four weeks postoperatively, the patient presented to our institution for progressive swelling in the LUE and neck. CT angiography (CTA) imaging demonstrated an increase in the amount of DVT in the subclavian vein and new DVT within the left internal jugular vein. The patient had no improvement in the LUE flail arm. Consequently, the patient was admitted, and a heparin drip was initiated.

Further diagnostic studies were performed. Nerve conduction studies showed the absence of median, ulnar, and radial sensory responses, and decreased amplitude of median and ulnar motor responses. An electromyography study showed profuse active denervation with no motor units throughout the muscles of the entire LUE (Table 1).

Imaging with CTA of the chest and magnetic resonance imaging of the left BP demonstrated relative narrowing of the costoclavicular space to 8 mm (Fig. 1a) and diffuse edema of the BP (Fig. 1b), most prominent proximal to the costoclavicular space. Additionally, the scapula on the left side was significantly medialized compared to the right side (Fig. 1c). Typically, the costoclavicular interval measures 12 mm [4].

Given the clinical, electrophysiological diagnostics, and imaging findings, severe BP stretch resulting in LUE flail arm was suspected. Risks and benefits of first rib resection were discussed, and the patient wished to proceed. Intraoperatively, combined supraclavicular and infraclavicular exposure of the BP was performed for full assessment. The BP was observed to be pushed downward by the clavicle, and there was significant traction on the plexus, as well as medial and downward tension (Fig. 2a and b). It was apparent that the first rib resection would not relieve this traction. Complete claviculectomy was considered but felt to be non-optimal due to cosmetic considerations, as well as concern for causing shoulder instability. The surgical team opted for a dorsal claviculectomy, in which a high-speed drill was

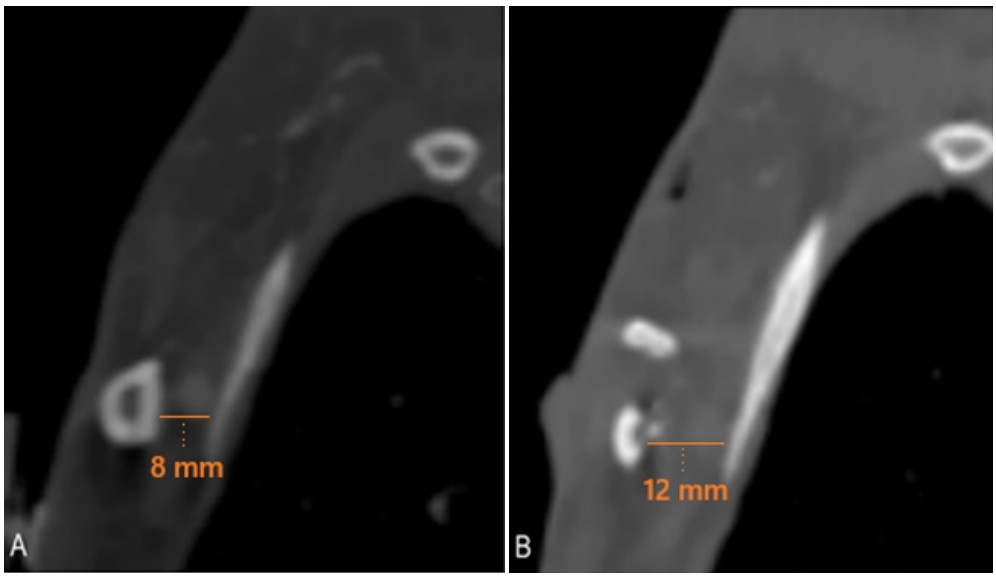

Figure 4: (a) Preoperative and (b) postoperative images illustrating the dorsal claviculectomy and widening of the costoclavicular interval, from 8 mm to 12 mm. Surgical drain in view in the post-operative image.

Muscle	Insertional/spontaneous					Volunt		Motor	Unit	POT
	ins	other	pwave	fib	fasc	eff	rect	amp	dur	poly
L-anterior deltoid	I	0	sust	4+	0	N	0			
L-pectoralis major	I	0	sust	4+	0	N	0			
L-latissimus dorsi	I	0	sust	4+	0	N	0			
L-supraspinatus	I	0	sust	4+	0	N	0			
L-infraspinatus	I	0	sust	4+	0	N	0			
L-rhomboids	N	0	0	0	0	N	N	N	N	N
L-upper trapezius	N	0	0	0	0	N	N	N	N	N
L-FDI (hand)	I	0	sust	4+	0	N	0			
L-biceps brachii	I	0	sust	3+	0	N	0			
L-deltoid	I	0	sust	3+	0	N	0			
L-ext digitorum communis	I	0	sust	4+	0	N	0			
EMG: Electromyography, I: increased, L: left, N: normal, sus: sustained										

Table 1: Patient's EMG results.

used to resect the dorsal half of the clavicle (Fig. 3a, b, c). Thin malleable retractors were used to protect and gently retract the BP to prevent injury with the drill and to allow working room for the drill (Fig. 3b). The dorsal cortical rim of the clavicle was removed, as well as most of the medullary bone. This resulted in the removal of approximately 50–60% of the clavicle cross-sectional area in the region where the BP crossed. This procedure was chosen to reduce the amount of traction on the BP and relieve the stretch injury, while avoiding the morbidity of a full claviculectomy. Postoperative imaging showed the extent of the dorsal claviculectomy, especially in comparison to preoperative imaging (Fig. 4a and b). A heparin drip was resumed shortly after surgery.

Postoperatively, the patient remained in a sling at all times for 2 additional weeks, until she completed a total of 6 weeks of postoperative sling immobilization following her initial scapulothoracic fusion. Following this, she wore a sling only when out of bed to support her arms weight as her BP injury recovered. Two days postoperatively, the patient began to activate finger flexion. At 4 weeks postoperatively, she could still activate finger flexion as well as finger extension and abduction. She initiated structured physical therapy at this time 2–3 times weekly to help improve range of motion and promote movement and recovery. At 4 months postoperatively, she showed greater than antigravity strength in finger flexion extension, wrist flexion, extension, and elbow extension but had weak activation of elbow flexion and shoulder abduction. At 6 months postoperatively, she had Medical Research Council (MCR) four/five strength throughout her entire LUE. At 12 months postoperatively, she had full strength in shoulder and elbow function, and a MCR strength of four plus/five wrist and finger function, with continued improvement.

Discussion

Scapulothoracic fusion is an established treatment for scapular stabilization in cases of instability, such as FSHD, among other indications. A known complication of this procedure is BP injury. Previously described strategies for this complication include reoperation to adjust the scapula's position on the chest wall, first rib resection, and watchful waiting. This case report is the first, to our knowledge, to describe the use of dorsal claviculectomy for the treatment of BP stretch injury.

BP injuries have been reported to occur at a rate of 2.5–8.3% after scapulothoracic fusion for FSHD [3, 5, 6]. From 1906 to the present, multiple reports have detailed BP injuries from scapulothoracic fusion, along with their treatments and outcomes [6, 7, 8, 9, 10, 11, 12, 13, 14], as summarized in Table 2.

Consensus on the exact mechanism of BP injury in patients with

Table 2: Literature review on brachial plexus injuries

Authors	Year	# of cases	# of BP injuries	% patients affected	Management	Outcomes
Putti [7]	1906	1	1	NA	Reoperation for clavicular lengthening	Improvement after reoperation, incomplete recovery
Bunch and Siegel [8]	1993	17	1	5.90%	Nonoperative management	Fully recovered in 6 months
Twyman et al.[6]	1996	12	1	8.30%	Nonoperative management	Upper trunk palsy did not improve over 6 years of follow-up
Berne et al.[9]	2003	49	2	4.10%	Nonoperative management	Median and radial nerve palsies resolved within 6 months
Mackenzie et al.[10]	2003	1	1	NA	Reoperation to adjust scapular position	Fully recovered within 2 years postoperatively
Wolfe et al.[11]	2005	2	2	NA	First rib resection to decompress the thoracic outlet	Partial but incomplete recovery of upper trunk palsy after first rib resection for thoracic outlet decompression
Glenn and Romero [12]	2005	32	2	6.30%	First rib resection	Improvement after reoperation, with incomplete recovery
Bhatia et al. [13]	2012	1	1	NA	Intraoperative scapula repositioning	Transient palsy that resolved fully with scapula repositioning
Cooney et al. [14]	2014	14	1	7.10%	Nonoperative management	Resolved completely over 27 months
Eren et al. [3]	2020	40	1	2.50%	Nonoperative management	Partial recovery by 18 months with persistent long-term ulnar nerve deficits

scapulothoracic fusion does not exist. The predominant theory is that the BP is directly compressed between the first rib and clavicle. As the scapula is translated inferiorly and medially, the clavicle is also pulled toward the first rib through the acromioclavicular joint, causing narrowing of the costoclavicular space of the thoracic outlet. However, another possibility, as reported in our case, is the downward and medial stretch of the BP by the clavicle as the scapula is mobilized.

Surgical treatments described in the literature have focused on (1) superior and lateral repositioning of the scapula to expand the costoclavicular space, as well as (2) first rib resection to further open the space. Both treatment strategies would be effective for a compressive mechanism of action. However, if the mechanism of action is due to a stretch injury of the BP by the clavicle, only surgical repositioning of the scapula, or clavicular osteotomy or resection, could improve the stretch. Rib resection would not be expected to have a therapeutic effect on the downward and medial stretch by the clavicle.

With dorsal or partial claviculectomy, there is a theoretically increased risk of clavicle fracture given the removal of a large portion of the clavicular structure. For this patient, this risk was ameliorated by her scapulothoracic fusion, which limited the movement of the clavicle. Additionally, numerous studies on partial claviculectomies within the oncology literature report high functional outcomes without any reported clavicle fractures [15].

Procedures focused on the clavicle have been described for scapulothoracic fusion for Sprengel's deformity [16], where a high degree of caudal reduction is required for treatment of a congenital high-riding scapula. This more aggressive reduction is particularly high risk for neurovascular complications such as BP injury. For this indication, techniques such as excision of part of the clavicle, morcellation of the clavicle, clavicular lengthening [7], and clavicular osteotomy have been described [16]. Some of these techniques, such as complete clavicle excision, clavicular osteotomy, and clavicular morcellation, would likely also have been effective in relieving the BP stretch for this patient. However, they would come at the cost of a full clavicular disconnection which would increase the level of invasiveness and risk of perioperative and future complications [17, 18]. To our knowledge, dorsal claviculectomy as a prophylactic or treatment measure for BP stretch or compression has not been described in the context of scapulothoracic fusion or any other setting.

Additional strategies to help prevent and manage BP injuries related to scapulothoracic fusion procedures include the use of intraoperative neuromonitoring, performing intraoperative pulse checks of the distal upper extremity as a surrogate measure of neurovascular function, and early diagnosis and treatment if BP injuries occur.

Conclusion

BP and other neurovascular injuries are known complications of scapulothoracic fusion that can significantly affect quality of life. Downward stretch of the BP and narrowing of the costoclavicular interval are likely mechanisms for this type of injury, and dorsal claviculectomy can be considered as a treatment option to relieve the stretch and compression of the BP. Familiarity with this complication and measures to prevent and treat it are paramount for optimizing patient outcomes.

Clinical Message

This article substantiates the utility of dorsal claviculectomy as an innovative treatment for brachial plexus injury post-scapulothoracic fusion, altering clinical practice by emphasizing early diagnosis and targeted interventions for improved patient outcomes.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil **Source of support:** None

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