Scapulothoracic Fusion With Nonmetallic Cables

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Abstract: The scapulothoracic motion plays an important role in shoulder elevation and abduction. Facioscapulohumeral dystrophy, peripheral nerve injuries, medial clavicular insufficiency, brachial plexus, and spinal cord injuries can cause loss of scapular stabilization, resulting in painful winging of the scapula. Scapulothoracic fusion is a salvage procedure that aims to address this problem by providing a stable base for the scapula on the thorax. The indications for this procedure include refractory pain and limitation in shoulder elevation secondary to scapular winging. Different techniques on scapulothoracic fixation have been described in the literature with favorable outcomes. We report on the technique of scapulothoracic fusion performed on a patient with painful winging of the scapula secondary to the spinal cord injury. In this technique, we preferred to use nonmetallic cables, polyester tapes, and a low-profile plate to avoid possible complications associated with scapulothoracic fixation, such as a stress fracture of the ribs and implant cutoff through the scapula.

Key Words: scapulothoracic fusion, arthrodesis, supercable, scapular winging

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The scapulothoracic mechanism allows riding of the concave anterior surface of the scapula on the convex posterolateral surface of the thorax and accounts for one third of total motion during shoulder abduction and elevation.[1] Disorders affecting the periscapular muscles such as facioscapulohumeral dystrophy (FSHD), injury to the nerves that innervate periscapular muscles such as long thoracic, dorsal scapular, or spinal accessory nerves, medial clavicular insufficiency, and brachial plexus or spinal cord injuries can result in loss of scapular stabilization.[2] This causes subsequent loss of glenohumeral motion and painful scapular winging. Scapulothoracic stabilization procedures that aim to address these problems include muscle transfers, scapulopexy, and arthrodesis.

Pectoral muscle transfers with fascial graft interposition have been described for use in patients with scapular winging secondary to nerve palsies.[3–5] Although the reported results are satisfactory, the indication for muscle transfer procedures is limited to serratus anterior and trapezius palsy.

Scapulopexy involves surgical stabilization of the scapula on the thoracic wall with soft-tissue slings. The technique for this procedure is based on fixing the scapula to the vertebral spinous processes or the underlying ribs by using fascial strings. Different modifications of the technique have been described in the literature, including using fascia lata strips or Mersilene tape to stabilize the scapula to the spinous processes, ribs, or the contralateral scapula alone or with concomitant muscle transfers.[6–9] Despite the advantages of this procedure, such as less rigid fixation and early postoperative mobilization, the results generally deteriorated over time because of the attenuation and loosening of the fascial slings.[10]

First described in 1961,[11] scapulothoracic arthrodesis has been used for stabilization of the scapula on the thorax with implants. The proposed techniques for scapulothoracic fixation include using screws, stainless steel wires, monofilament cables, and plates with screws or wires.[12–16] Regardless of the type of fixation, various bone grafting methods such as posterior iliac crest autograft and humeral or tibial allograft bone struts have been generally used in conjunction with scapulothoracic fixation.[17,18] The reported outcomes of this procedure are satisfactory, providing pain relief and improvement in range of motion (ROM) in mid-term to long-term follow-up.[19]

We present the senior author's (R.F.W.) preferred technique for scapulothoracic fusion with nonmetallic cables, polyester tapes, and a low-profile plate, and report on a patient with painful winging of the scapula secondary to the spinal cord injury that was treated with this technique.

CASE REPORT

The patient is a 37-year-old female who was involved in a motor vehicle accident 17 years ago that resulted in an incomplete C5-7 quadriplegia. She subsequently underwent a cervical fusion on these levels and developed some function in her bilateral upper extremities that was limited to muscles innervated by musculocutaneous and axillary nerves with a small contribution by the radial nerve. She was born right-hand dominant but started to function as a left-hand dominant because of the better ROM and strength on this side. Her main complaint was debilitating pain (10/10 on Visual Analog Scale) around her right shoulder girdle that developed over the last 3 years when she noted a progressive superomedial tilt of the scapula that limits shoulder abduction (Fig. 1). She had extensive night pain that was unresponsive to analgesic medications and had attempted a long course of formal physical therapy, periscapular Botox injections, and bracing without relief. Physical examination revealed a generalized weakness and wasting of the rhomboid, pectoralis, latissimus, and serratus muscles with a painful winging scapula. She had maintained anterior deltoid function that enabled her to perform 70 degrees of forward elevation and 60 degrees of abduction. During the Horwitz maneuver[20] (active elevation while the scapula is stabilized against the thoracic wall by the examiner), the elevation arc was noted to improve up to 110 degrees. Given her reliance on her upper extremities for daily activities and significant disability due to chronic pain and scapular winging, it was decided to proceed with a scapulothoracic fusion after a detailed discussion with the patient and pulmonary evaluation with pulmonary function tests that were felt to be sufficient to allow a scapulothoracic fusion.

Operative Technique

After the induction of general anesthesia, the patient was positioned prone on the operative table with all bony prominences appropriately padded. The right upper extremity and posterior iliac crests were prepped and draped in the sterile field. Before making the skin incision, the contralateral posterior iliac crest was aspirated for 60 mL of bone marrow aspirate. This was spun down for later use with bone morphogenic protein (BMP-2; Medtronic, Minneapolis, MN) for bone grafting. A 5 inch longitudinal skin incision was made midway

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FIGURE 1. Preoperative anteroposterior and lateral scapular (Y) views demonstrating scapular winging of the right shoulder.

between the medial border of the scapula and the spinous processes of the upper thoracic vertebrae. After the longitudinal splitting of the subcutaneous tissues and the trapezial fascia, the trapezius and underlying rhomboid musculature were dissected from the medial border of the scapula and tagged with sutures for retraction. The medial portions of the serratus anterior and subscapularis muscles, as well as the subscapularis bursa, were identified and excised for visualization. The dissection was carried down to the bone in the supraspinatus and infraspinatus fossa along the medial border of the scapula for adequate identification of the scapular spine and the medial aspect of the membranous portion of the scapula for suture passage and placement of the plate. Once the medial scapular border was completely identified, a towel clamp was placed on the scapular spine for improved visualization and mobilization. The soft tissues were freed up from the anterior scapula with a 5 mm burr and periosteal elevators. The underlying 5 ribs (2 to 6) were then identified and the electrocautery was used to complete a subperiosteal dissection by taking care to protect the intercostal vessels and nervous structures along the inferior border of the ribs. The periosteal elevators and rib strippers were used to separate the ventral aspect of the ribs from the parietal pleura and clear the ribs circumferentially for passage of cables and tapes. The posterior aspects of the ribs were also decorticated with a burr to create a bleeding surface for bony fusion (Fig. 2A).

The previously placed towel clamp was used to mobilize the scapula to the planned location of the scapulothoracic fusion. The level of the identified ribs and the correct alignment of the fusion site were checked with intraoperative x-ray images. The fixation to the scapula was performed through 4 consecutive ribs beginning at the level of the scapular spine and moving caudally. The third thoracic rib was identified for placement of the initial cable at the level of the spine of the scapula. A nonmetallic cable (SuperCable, Kinamed Inc., Camarillo, CA) was passed with the use of a suture shuttle through a hole created in the supraspinatus fossa just superior to the scapular spine with a burr. The cable was then passed around the rib and subsequently back through a hole created in the infraspinatus fossa just inferior to the scapular spine. The fourth rib was also cleared of periosteum, however, because of the poor bone quality at this level, a polyester (Mersilene, Ethicon Inc., Somerville, NJ) tape was used for passage through the membranous portion of the medial aspect of the scapula around the rib and around the medial cortex of the scapula. A second polyester tape was used inferior to that and 2 subsequent nonmetallic cables were passed in the same manner through the medial portion of the scapula around the ribs and back over

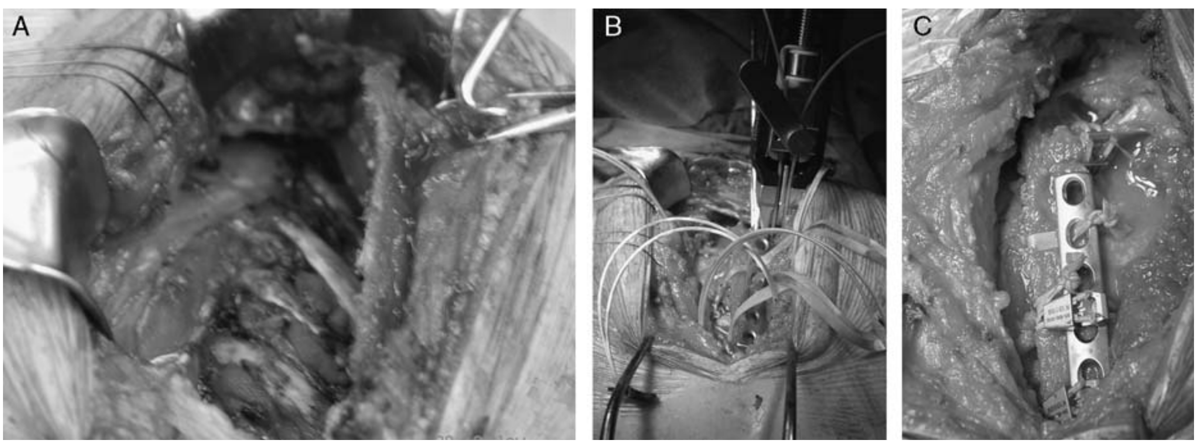

FIGURE 2. A, Intraoperative photograph demonstrating the scapulothoracic articulation after preparation of the bony surface of the ribs and the scapula for arthrodesis. B, Tensioning of the construct over the plate after passage of cables and tapes around the ribs (3 to 6) and through holes created in medial aspect of the scapula. C, Final position of the scapula after bone grafting and tensioning of the cables.

the medial border of the scapula inferiorly. The second rib was also decorticated on its posterior aspect for bony fusion but a cable or tape was not passed around it in the supraspinatus fossa.

Before tensioning the cables and tying the polyester tapes, we added the previously collected bone marrow aspirate to BMP-2 and placed it within the region of scapulothoracic fusion created between the posterior aspect of the ribs and the anterior aspect of the scapula, in addition to the bone morphogenic protein and cancellous allograft chips. Once the graft was placed, the tensioning device for the non-metallic cable was used initially on the cable at the level of the scapular spine with optimum tensioning and reapproximation of the scapula to the planned location (7 cm lateral to the spinous process) proximally (Fig. 2B). Two polyester tapes were then tied sequentially through a precontoured, 4.5 mm 6-hole titanium plate (Synthes, West Chester, PA) placed on the posterior aspect of the scapula with reinforcement at its membranous portion. The inferiorly placed 2 nonmetallic cables were finally tensioned around the plate to prevent them from cutting through the weak medial border of the scapula (Fig. 2C). The scapulothoracic fixation was achieved in a position such that the angle between the spinous processes and the medial border of the scapula measures approximately 20 degrees, as fixation at more acute angles (< 10 degrees) restricts abduction, whereas fixation at larger angles (> 30 degrees) limits adduction.[21] After the scapulothoracic fixation, there was no translation of the scapula on the thoracic wall under direct visualization with movement of the arm. We preferred to use nonmetallic cables and polyester tapes to prevent a possible stress fracture of the ribs and a low-profile plate to avoid the implants cutting off through the scapula. Before proceeding with closure, the wound was filled with saline and a Valsalva maneuver performed by the anesthesia team revealed that there was no evidence of any pleural peak. The rotator cuff and periscapular muscles were reapproximated with #2 nonabsorbable sutures. A single drain was placed in this layer and a second drain was placed in the more superficial layer. The wound was then closed in layers.

The patient had an uneventful recovery period during her 8-day hospital stay and subsequent clinic visits. She was kept in a shoulder brace with an abduction pillow for 10 weeks. Passive ROM exercises were started at 2 weeks. Active ROM and strengthening exercises were initiated after 3 months. She improved gradually over the course of 1-year follow-up, reporting pain relief and improved ROM. During her last office visit, she had a significant pain relief (2/10 vs. 10/10) with a 40-degree improvement in forward elevation (110 degrees) and a 45-degree improvement in abduction (105 degrees) that allowed her to perform daily activities and personal care. There was an evidence of bony fusion between the scapula and the thorax on 1-year follow-up radiographs (Fig. 3).

DISCUSSION

The main advantage of scapulothoracic arthrodesis over scapulopexy is the reinforced scapular fixation obtained by bony fusion between the articulating surfaces. This feature makes the procedure more applicable to the patients with a global upper extremity weakness pattern such as that seen in spinal cord injury. The achieved bony fusion provides an inherent stability that compensates for the loss of motor function in scapular stabilizers. Overall, muscle transfers and scapulopexy have a more limited use in this patient group. The limited indication for muscle transfers is the painful scapular winging secondary to long thoracic or spinal accessory nerve damage and this limits their use in FSHD or spinal cord injury.[19] Scapulopexy has been commonly performed in setting of FSHD or isolated nerve palsy,[3–5] however; there are no reports of its use in patients with spinal cord injury. Given the more generalized upper extremity weakness and their reliance on upper extremity for daily functions, a formal arthrodesis can be a more predictable option than scapulopexy in this group of patients.

Despite the theoretical advantage of providing a more stable base for the scapula on the thorax with bony fusion, the scapulothoracic arthrodesis procedure has some major disadvantages. A limitation in expansion capacity of the thorax and the prolonged immobilization period required to achieve fusion are the consequences associated with the inherent dynamics of the arthrodesis procedure. One study reported an average reduction in vital capacity as 21% but this rate can be as high as 50% after bilateral surgical procedures.[13] Our patient had mild (5%) vital capacity loss preoperatively on pulmonary function tests that was felt to be sufficient for a scapulothoracic fusion. She did not experience any pulmonary problems after surgery. The proposed immobilization period after scapulothoracic arthrodesis varies between 6 and 12 weeks, whereas it is significantly shorter (2 to 3 weeks) after scapulopexy and muscle transfers. This poses an increased risk in the development of postoperative shoulder stiffness and adhesive capsulitis with rates reported around 10% in different series after scapulothoracic arthrodesis.[11,22] Overall, the prevalence rates of complications associated with the arthrodesis procedure vary and have been as high as 75% in

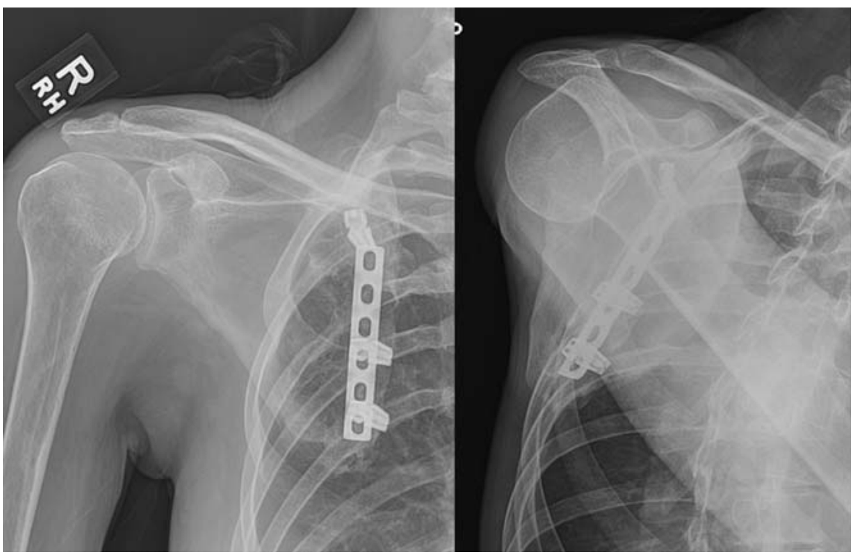

FIGURE 3. One-year follow-up radiographs demonstrating the corrected alignment of the scapula on the thorax.

the literature.[11] These include pneumothorax/hemothorax, pleural effusion, brachial plexus palsy, stress fractures in scapula and ribs, skin breakdown, nonunion, and implant failure. The rates of more serious complications such as pneumothorax and brachial plexus palsy have been relatively less common (<5%) and all these had resolved without any further intervention.[12,15] We did not experience any of these complications in our patient. The risk of nonunion after scapulothoracic arthrodesis has been reported as high as 25%.[2] In a series of 9 patients (16 shoulders) who underwent scapulothoracic arthrodesis by transfixing a rib through a hole created in the medial border of scapula with plate, screws, and wires, Letournel et al[15] reported rib fractures in 2 patients and pseudoarthrosis in 1 patient, bilateral scapular stress fractures in 1 patient, and wire breakage in 1 patient. Twyman et al[13] reported on 6 patients with FSHD who underwent bilateral scapulothoracic fusion with 18 G Luque wires passed around ribs and through holes created in the medial scapular border. The complications were reported as symptomatic nonunion in 1 patient, wire breakage in 3 patients, and rib stress fractures in 1 patient. In another series of 25 patients (32 shoulders) operated on using 3.5 mm reconstruction plate and 18 G Luque wires, the authors reported wire failure in 3 patients, nonunion in 2 patients, and scapular fracture in 1 patient.[10]

The review of the existing literature suggests that the most common complication after scapulothoracic fusion is implant-related problems such as implant failure, skin breakdown, and stress fractures caused by the implants cutting through the bone. Furthermore, additional surgery is generally required for revision of these complications unless they are asymptomatic or have the potential to heal by themselves. To address this issue, several modifications in scapulothoracic fixation techniques have been proposed. The first modified technique was described by Ketenjian[21] in 1978. Mersilene tapes were passed around the ribs and through drill holes created in medial aspect of the scapula to achieve scapulothoracic stabilization without bony fusion in this technique. A modification of this technique was described by Atasoy and Majd[23] in 2000. They used autogenous fascia lata strips in the same manner to stabilize the scapula on the thoracic wall without bony fusion. A similar technique was recently used in 2 patients with spinal cord injury by Pahys et al.[24] In addition to the technique described by Ketenjian, the authors tied Mersilene tapes over plates placed on the scapula and fixed the plate to the underlying rib with a screw. Two other similar techniques with bony fusion were also described in the literature. In a case report by Szomor et al,[18] allograft Achilles tendon strips were passed around the ribs and through holes created in the scapula to achieve scapulothoracic fusion along with allograft and posterior iliac crest autograft. Recently, Demirhan et al[16] described a modified technique in a series of 13 patients. They used monofilament cables to fix the scapula over the underlying ribs along with iliac crest autograft, cancellous chips, and DBM.

These modified techniques have less complication rates when compared with the conventional methods, possibly because of the use of low-profile implants with higher load to failure rates. Taking this into account, we performed a modified technique of scapulothoracic fusion using nonmetallic cables and Mersilene tape. The cable construct is composed of a nylon interior base encased in a jacket of UHMWPE braided fibers, with a metal clasp for tightening and locking. It is a strong construct primarily used in periprosthetic fixation in revision hip arthroplasty and early results suggest that it is not associated with material failure.[25] We preferred to use the nonmetallic cable as the primary fixation implant for scapulothoracic arthrodesis in this case; however, it was not possible to use it on the fourth rib because of the decreased bone quality. Therefore, 2 Mersilene tapes were used on the fourth rib to prevent a possible stress fracture as the tapes have a wider contact area and less stiffness when compared with the nonmetallic cables. A plate was also placed on the scapula before tensioning of the final construct to prevent the cables and tapes from cutting through the thin medial border of the scapula.

The technique of scapulothoracic stabilization without bony fusion has been associated with favorable outcomes in terms of pain relief but its results have been less predictable with respect to functional improvement.[21,23,24] Fasciodesis also offers the advantage of early postoperative mobilization, which makes it more feasible in most clinical settings with scapular winging such as isolated nerve injuries and FSHD. However, this was not applicable in this case because our patient had gross dysfunction of the periscapular musculature accompanied by a global upper extremity weakness pattern due to the high-level spinal cord injury and was completely dependent on her upper extremity function for mobilization and personal care. Therefore, we preferred to perform a formal arthrodesis procedure to incorporate the bony fusion in scapulothoracic stabilization provided by implant fixation.

CONCLUSIONS

We conclude that the scapulothoracic fusion may provide satisfactory clinical results in the setting of painful scapular winging secondary to high-level spinal cord injury. Fixation with low-profile implants such as nonmetallic cables and polyester tapes is a viable option with a low potential of morbidity. Appropriate implant selection may help the surgeons in avoiding possible complications associated with scapulothoracic fixation, such as a stress fracture of the ribs and implant cutoff through the scapula.

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