Conservative Management of Superior Subluxation of the First Rib

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First rib subluxation is one possible cause of neck, shoulder, and arm pain. The anatomy and biomechanics of the first rib contribute to its tendency to sublux superiorly. Management of first rib subluxation may include manipulative therapy, therapeutic exercises, pharmaceutical agents, and physical modalities to correct joint dysfunction, decrease soft tissue tension, and prevent recurrence.

Neck, shoulder, and arm pain are common symptoms reported by athletes. Many musculoskeletal lesions can be the source of this pain. A relatively common dysfunction that can cause neck, shoulder, and arm pain is superior subluxation of the first rib (10). Superior subluxation of the first rib has been reported to occur more commonly prior to age 50 and be more frequent in young adults (10). Due to the complexity of the neck/shoulder complex and the covert nature of this dysfunction, superior subluxation of the first rib may escape diagnosis (10, 13, 37). First rib dysfunction can go undetected and untreated, and might be the cause of persistent chronic cervical and brachial pain.

The sympathetic (stellate) ganglion, first thoracic (T1) ventral ramus, lower trunk of brachial plexus, first intercostal nerve and vessels, and subclavian artery lie in the immediate vicinity of the first rib and its costotransverse and costovertebral joints (19, 41, 42). Superior subluxation of the first rib can cause mechanical as well as inflammatory irritation of the above neural and vascular elements, producing the symptoms observed (13, 19, 41). The first rib has been implicated as a possible cause of thoracic outlet syndrome (TOS) and reflex sympathetic dystrophy (19, 26). First rib dysfunction will be treated as a separate entity from thoracic outlet syndrome. A review of the anatomy and biomechanics of the first rib, factors involved in first rib dysfunction, and evaluation and treatment techniques to aid in the diagnosis and management of first rib dysfunction will be covered. In addition, an integration of anatomical factors with theories and techniques of different disciplines will be explained in the culmination of a comprehensive treatment approach for first rib dysfunction.

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Review of the Literature

Anatomy

The First Rib. The ribs are curved bones that connect the vertebral column to the sternum, forming the rib cage and thoracic cavity. The ribs form three articulations with their adjacent structures. The heads of the ribs articulate with the bodies of the vertebrae, forming the costovertebral joints. The tubercles of the ribs articulate with the transverse processes of the perspective vertebrae, forming the costotransverse joints. The sternal ends of the ribs join the costal cartilage, forming the costochondral joints. The rib cage contributes to stability and stiffness of the spine (30). The first costovertebral and costotransverse joints are synovial while the first costosternal joint is a synarthrosis (8, 42).

The first rib is atypical in shape and function. It is a broad, flat, short rib and the most acutely curved. It has no angle or costal groove. In the average adult, it is 7.62 cm long from the vertebral column to the costomanubrial junction (29). The distance from the center of the seventh intervertebral foramen to the concavity of the first rib is 5.08 cm (29). The first rib slopes obliquely, anteriorly, and inferiorly from its head to its sternal end. The costovertebral joint of the first rib is unlike the typical ribs (II-X), which articulate by two hemifacets with two vertebral bodies and the intervening intervertebral disc. The first rib, like the 11th and 12th ribs, articulates with one vertebral body (TI) via a small round head (7, 41, 42). This distinct feature, in addition to attachment of the powerful scalene muscles and lack of superior ligamentous support at the first costotransverse joint, may contribute to the tendency of the first rib to sublux superiorly in the inspiration position (10, 19, 20, 28, 36).

The first ribs form the lateral borders of the thoracic inlet which is bound anteriorly by the sternal manubrium and posteriorly by the first thoracic vertebral body (42). Several neural and vascular elements lie in close proximity to the first rib and its costotransverse and costovertebral joints. The sympathetic cervicothoracic (stellate) ganglion lies anterior to the neck of the first rib and lateral to the first costovertebral joint (19, 41, 42). The first thoracic ventral ramus ascends across the neck of the first rib to enter the brachial plexus (42). The first intercostal nerve lies posterior to the first and second costovertebral joints (41). The first rib is the base of the costoscalene triangle, which is formed by the middle and anterior scalene muscles. Through the costoscalene triangle pass the brachial plexus and subclavian artery. Irritation of these neural elements may produce symptoms observed in first rib dysfunction (13, 19, 41).

Muscular Attachments. The first rib serves as an attachment site for several muscles. The anterior scalene muscle attaches to a tubercle on the first rib. The first rib is also site of insertion of the middle scalene muscle, subclavius muscle, and first digitation of the serratus anterior (see Figure 1). The levator costarum muscle also inserts on the superior posterior aspect of the first rib (42). The longissimus thoracis sends a slip that inserts on the inferior posterior margin of the first rib (8). The superior aspect of the first rib also serves as an attachment site for the costoclavicular ligament (42). The costoclavicular ligament transfers any superior pull on the clavicle to the first rib, thereby contributing to superior subluxation of the first rib.

There are several muscular attachments on the superior aspect of the
clavicle. The upper portion of the trapezius muscle and the sternocleidomastoid muscles are capable of elevating the clavicle (42). Elevation of the clavicle may lead to elevation of the first rib through the costoclavicular ligament.

**Scalene Muscles.** The scalene muscles play an important role in first rib dysfunction. The anterior scalene muscle originates from anterior tubercles of the transverse processes of the third through sixth cervical vertebrae. The musculotendinous slips converge to a narrow, flat tendon that inserts on the scalene tubercle of the first rib (see Figure 1). The anterior scalene is innervated by the ventral rami of the fourth through sixth cervical spinal nerves (42).

The middle scalene is the largest and longest of the scalene muscles. It originates from the posterior tubercles of the transverse processes of the second through seventh cervical vertebrae. The middle scalene inserts on the first rib between the scalene tubercle and subclavian groove (see Figure 1). The middle scalene is innervated by the third through eighth cervical spinal ventral rami (42).

The posterior scalene is the smallest of the scalene muscles. It originates from the posterior tubercles of the transverse processes of the fourth through sixth cervical vertebrae. The posterior scalene descends anterior to the first rib.
to insert on the external border of the second rib. The posterior scalene is innervated by the sixth through eighth cervical spinal ventral rami (42). The function of the scalene muscles is listed below.

- Anterior and middle scalene: lateral flexion and contralateral rotation of the neck; elevation of the first rib.
- Posterior scalene: Lateral flexion of the lower cervical vertebral column; elevation of the second rib (18, 42).

Biomechanics

The thoracic cage protects the vital organs and is involved in respiration. Inhalation involves movement of the ribs in an anteroposterior and lateral dimension as the chest wall expands. The movement in an anteroposterior direction is known as the pump handle motion, and lateral excursion is known as the bucket handle motion. The contribution of these movements to total rib excursion is a function of each rib's axis of motion. The costovertebral and costotransverse joints form a complex coupled joint. The axis of motion of each rib is an imaginary line drawn between the costovertebral and costotransverse joints (Figure 2). The upper ribs have more pump handle motion than bucket handle motion because their axes of motion lie closer to the coronal plane (7, 9, 28). Conversely, the lower ribs have more bucket handle motion than pump handle motion because their axes of motion lie closer to the sagittal plane (7, 9, 28).

**First Rib Movement.** First rib motion has been proposed to have equal pump and bucket handle motion (28), greater proportion of pump handle motion (7), and all pump handle motion (36). Stoddard (36) proposed that although normal first rib motion is of the pump handle type, lesions of the first rib are bucket handle type. Thus there is no consensus in the literature on the issue of first rib movement.

Haines (11) proposed that the axis of movement of the first rib is an oblique
one (in relation to a line drawn horizontally through the costovertebral joint). The axis passes through the head of the first rib, along its neck, and through its tubercle, and is directed laterally, posteriorly, and slightly superiorly. In Haines’ (11) review of literature that dates back to the 1700s, the obliquity of the first rib’s axis ranges from 9 to 42°. Haines reported 35° of obliquity of the axis of the first rib in the cadaver he studied.

The first rib in the specimen studied by Haines (11) could move through a range of 24°. The sternal end of the first rib could move 31 mm. This displacement was further broken down to 28 mm of vertical and 14 mm of anterior motion. The maximum distance between the lateral borders of the two first ribs was found to increase by 9 mm from the resting position. The distance between the costochondral junction of the two first ribs was found to be unchanged when the first ribs were in the inspiration position (11).

In living subjects, estimates of rib motion appear to agree with the estimates made in cadavers (11). The first rib was estimated to displace a mean of 21 mm superiorly and 15 mm anteriorly. Radiographically, the lateral excursion of the first ribs was found to be 8–9 mm (11).

Muscles capable of elevating the first rib are listed below:

- Anterior scalene: through direct insertion on the first rib (23, 42);
- Middle scalene: through direct insertion on the first rib (23, 42);
- Iliocostalis cervicis: through direct insertion on the first rib (23);
- Levator costarum: through direct insertion on the first rib (23, 42);
- Sternocleidomastoid: indirectly through its attachment on the clavicle (2, 23).

Electromyographic studies show that the scalene muscles evidence rhythmic increases and decreases in activity with inspiration and expiration (2). The first intercostal muscles were found to be constantly active, with no rhythmic increase or decrease. The scalene, internal intercostal, and sternocleidomastoid muscles were found to show marked activity with forced inspiration (2).

It is not known definitively whether any muscles are capable of depressing the first rib. Magee (23) has proposed that the longissimus thoracis is capable of depressing the first rib. The line of pull of the longissimus thoracis suggests that it may be capable of depressing the first rib if the muscle’s origin (middle layer of thoracolumbar fascia, lumbar transverse, and accessory processes) (42) is fixed. There is no agreement about whether internal intercostal muscles of the first rib are capable of depressing it (42).

Pathomechanics of First Rib Subluxation. Mitchell et al. (28) state that superior subluxation is unique to the first rib. Superior subluxation can occur due to attachment of the powerful scalene muscles on the first rib as well as to other anatomical characteristics, which were reviewed in the section on anatomy of the first rib. Superior subluxation of the first rib may also be combined with some degree of anterior or posterior subluxation (3, 28). The anterior or posterior subluxation is determined by the resultant vector of pull of the scalene muscles. Most literature cited suggests that elevation of the first rib involves elevation at the costovertebral and costotransverse joints as well (3, 10, 19–22, 26, 28, 34). However, Hoag et al. (13) and Stoddard (36) suggest that superior subluxation of the first rib involves elevation of the rib shaft and depression of its head at the costovertebral joint.
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According to Mitchell et al. (28), superior subluxation of the first rib is maintained because a small part of the first rib catches on the superior surface of the transverse process of T1. They state that reduction of the superiorly subluxed rib requires translation of the first rib anteriorly and laterally to dislodge it from the transverse process of T1. The scalene muscles tend to contract reflexively in the presence of superior first rib subluxation (8, 10, 13, 28, 32–34). Scalene muscle spasm contributes to the maintenance of first rib subluxation. Tension in the anterior scalene muscle will prevent anterior translation of the first rib, which is important for its reduction (28).

Somatic Dysfunction

First rib subluxation can be considered a somatic dysfunction. Somatic dysfunction is an osteopathic term defined as an “impaired or altered function of related components of the somatic (body framework) system: skeletal, arthrodial, and myofascial structures, and related vascular, lymphatic, and neural elements” (28, p. 6). Although somatic dysfunctions include somatic lesions, not all such lesions are considered somatic dysfunctions. Fractures plus degenerative and inflammatory conditions are not considered somatic dysfunctions. Manipulation in its various forms is an effective and sufficient treatment for somatic dysfunctions (6).

Somatic dysfunction is an altered functioning of a joint and is diagnosed by three specific criteria. These criteria have been named the “A-R-T” of diagnosis. “A” denotes asymmetry of the position of the vertebrae or involved bone. “R” denotes restriction of motion within the boundaries of physiologic motion. Restriction is found by motion testing the involved joint in all planes of motion. “T” denotes tissue texture changes. Soft tissue such as skin, fascia, and muscle undergo palpable changes in the presence of somatic dysfunction (6). Examples of these changes are edema, bogginess, hyperesthesia, hypoaesthesia, dryness, hyperhidrosis, nodule formation, muscle ropiness, and stringiness (6, 37). The words lesion, dysfunction, and somatic dysfunction will be used interchangeably.

Rib Dysfunction

Rib dysfunction has been classified into structural and respiratory dysfunctions (3, 4, 9, 28). Structural rib dysfunction involves subluxation or torsion of the rib (torsions usually do not involve the first rib). Structural rib dysfunction may be due to dysfunction of the thoracic or cervical joints. Subluxation of the first rib can occur due to scalene muscle spasm or dysfunction of the upper thoracic and upper (10) and/or lower (3) cervical vertebral joints. Treatment of the intervertebral joints may or may not correct the structural rib dysfunction. Structural rib dysfunctions may be associated with respiratory movement restrictions such as inhalation and exhalation restrictions (3).

Respiratory rib dysfunction is described as a limitation of rib motion, resulting in decreased excursions of the ribs on inhalation or exhalation. This dysfunction is often associated with cervical or thoracic joint dysfunction at the same level and may not necessarily be corrected with treatment of the vertebral joint. This type of restriction is seen by observing the rib, palpating it, and identifying the side that stops first when the patient takes a full inhalation or exhalation.
Factors Involved in First Rib Dysfunction

Since the first rib elevates with inspiration, a normal (nonelevated) first rib can be considered to be in a position of relative expiration. Because of the attachment of the powerful scalene muscles on the first rib, first rib lesions are usually inspiratory (i.e., "stuck" in the inspiration position) (28). First rib dysfunction can either be a primary lesion or secondary to a vertebral lesion (10, 32, 33, 37).

Primary first rib subluxation has been attributed to powerful pushing and pulling with the arm (10). Pushing with the elbow locked in extension has also been described as a possible mechanism of injury (32, 33). During an exertion involving the arm, the scalene, serratus anterior, subclavius, and intercostal muscles contract and may transmit forces to the first rib, in turn causing its subluxation (10). No radiographic studies have been performed to study first rib movement during activities that involve pulling and pushing with the arm (10). Trauma to the area of the first rib may also lead to fixation of the first rib in an elevated position (10, 13).

Somatic dysfunction of the cervical and upper thoracic spinal joints have been hypothesized to cause first rib subluxation (3, 10, 28). The first rib has close anatomical links with the cervical spine, cervicothoracic junction, scalene muscles, levator scapulae, and pectoral muscles (36, 37). The scalene muscles originate from all the cervical vertebrae with the exception of the atlas. Dysfunction of the cervical spine that includes facet or disc lesions can lead to irritation of the scalene muscles. In addition, the scalene muscles are innervated by the third through eighth cervical nerve roots. Nerve root irritation or other vertebral dysfunctions may result in scalene muscle spasm, which leads to elevation of the first and second ribs (37). First rib subluxation is most common, followed by dysfunction of Ribs II, V, and VI (32, 33). First rib dysfunction can be a primary or contributing factor in torticollis (32, 33).

Signs and Symptoms

The diagnostic criteria summarized below may aid in diagnosis of a subluxed first rib (3, 4, 8, 10, 19, 20, 28, 34):

1. Pain felt locally along the costovertebral, costotransverse, and costosternal joints of the first rib, or referred to the arm, neck, or head;
2. Restricted motion of the first rib in inhalation, exhalation, both, or positive E-I test;
3. Asymmetrical resistance felt to first rib springing;
4. Palpable displacement of the first rib at its head, anterior superior surface in the supraclavicular fossa, or its sternal end;
5. Presence of swelling, hyperesthesia, or tenderness at the head of the first rib, supraclavicular fossa, or costosternal joint of the first rib;
6. Positive cervical spine rotation and lateral flexion test;
7. Somatic dysfunction of the upper cervical, C7–T1, or T1–T2 vertebrae.

In addition to the above clinical features, upper cervical and suboccipital pain may be present (10). Cervical rotation toward the involved side and sidebending to the opposite side are restricted (10). Cervical extension is painful and flexion elicits a pulling sensation on the involved side. Shoulder movement
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on the involved side may be painful at the extremes of the range. Objective neurological signs are negative (10). Active or passive depression of the scapula may reproduce some of the symptoms (26). Unilateral posteroanterior pressure on the first rib or its costotransverse joint, or caudally directed pressure on the anterior or lateral aspect of the first rib, may reproduce some or all of the symptoms (26). The lesion is usually unilateral (10, 26). The upper trapezius as well as the scalene muscles are often in spasm, and tenderness can be elicited with palpation of the upper trapezius muscle (10). First rib subluxation has been reported to be associated with quadratus lumborum weakness and/or spasm of the scalene and levator costorum muscles (32, 33).

Paresthesia and dysthesia in the C8 and T1 nerve root distributions have been reported (19, 26). Proximity of the first costotransverse joint to the above nerve roots may explain these symptoms. Subluxation of the first rib may cause mechanical and inflammatory irritation of the C8 and T1 nerve roots (19). Reflex sympathetic dystrophy (RSD) signs and symptoms such as hand and forearm discoloration, sweating, swelling, clumsiness, and weakness have also been reported (19, 26). Subluxation at the first costotransverse joint can irritate the sympathetic ganglion, which may account for the RSD symptoms (19, 32, 33).

Radiographs may or may not show a superiorly subluxed first rib (10). Superior subluxation of the first rib has been reported to be visible on X-rays (25, 37), computerized tomography (CT) scans (25), and by cineradiography (19, 22). McCormick et al. (25) have reported a case that was visible on a CT scan, A-P radiographs, and cranially projected A-P radiographs. They reported that projecting the X-ray beam 20° cranially made the asymmetry more visible. The reader should be aware that McCormick et al. (25) describe this as superior “dislocation” of the first rib.

During observation, the patient may demonstrate slight side-bending toward the involved side while reaching with the opposite arm across the chest to rest the fingers on the painful upper trapezius area (10). The patient usually reports a dull ache over the upper trapezius on the involved side, which may be accompanied by unilateral hyperesthesia in the supraclavicular area (10). Headaches may be present (13, 19). Pain may also be referred to the deltoid or upper thoracic area (13), and the patient may report a feeling of heaviness in the involved arm (26).

Evaluation of the First Rib

Evaluation of the first rib includes observation of its static position, physiologic motion testing during inhalation and exhalation, and springing the first rib (4). Static position testing as well as motion testing is important for correct diagnosis of first rib dysfunction, since one alone may be misleading (due to presence of anatomical anomalies). For static position testing, the first rib should be palpated at three locations: (a) its superior posterior surface through the trapezius, (b) its anterior superior surface in the supraclavicular fossa, and (c) its sternal articulation just below the clavicle (4). In the presence of subluxation, the head of the first rib may be found to be 4 to 6 mm higher than the uninvolved side (3). Although it has been suggested that superior subluxation of the first rib may be accompanied by some degree of anterior/posterior subluxation (3, 28), there is no description of any techniques to evaluate the anterior/posterior component of the subluxation (3, 28).
Cervical ribs have been reported to be present in 0.5–1% of the population (40). It is important to rule out the presence of a cervical rib. If static position testing demonstrates that the involved first rib is higher than the uninvolved side by more than 2 cm, a cervical rib is suspected and manipulative treatment should not be performed (including thrust, mobilization, or muscle energy techniques) (28).

Specific testing of the first rib pump handle motion can be performed by placing the index finger in the first intercostal space and contacting the inferior portion of the first rib next to the sternal manubrium (Figure 3). The patient is asked to inhale and exhale deeply. Bucket handle motion of the first rib is tested by positioning the index finger 1 to 2 inches lateral to the manubrium. Lindgren and Leino (19) have described a similar test and named it the “expiration–inspiration test” (E-I test) (see Figure 3). The first rib is said to be superiorly subluxed if it is “stuck” in the inhalation position and does not return to the exhalation position (19, 28).

The accessory motion of the first rib can be evaluated by springing it inferiorly. The cervical spine is passively flexed, rotated away, and bent toward the involved side. The examiner’s index finger is placed on the posterior surface of the first rib just anterior to the trapezius, and an inferiorly directed force is applied on the first rib. Motion and resistance offered by the rib is compared bilaterally. A superiorly subluxed rib will offer more resistance to spring testing (4) and the patient may report localized or referred pain (8).

Lindgren et al. (20) describe a test that involves cervical rotation and lateral flexion and is positive in the presence of first rib subluxation. In this test the patient’s neck is passively rotated away from the involved side and then laterally flexed to bring the ear toward the chest on the involved side (Figure 4). This test is considered to be positive if the movement is restricted or a bony end feel is not present.

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Figure 3 — Pump handle motion testing of the first rib (also E-I test).
felt (20). The patient may report pain with this test. Lindgren et al. (20) suggest that restriction of combined cervical rotation and lateral flexion is due to bumping of the transverse process of T1 with the elevated first rib. There are no published studies that verify the reliability or validity of the above described tests.

Differential Diagnosis

Differential diagnosis should include other syndromes that could produce cervico-brachial pain and paresthesia. These include other causes of TOS such as cervical rib, hyperabduction, scalene anticus, costoclavicular compression, fractured clavicle, pectoralis minor, and scalene minimus syndromes (1, 31). In addition, nerve root compression by herniated discs, osteophytes, or lung neoplasm should be ruled out (25). Detailed discussion of the diagnostic criteria of the above syndromes is beyond the scope of this paper.

Treatment

Several methods of treatment of first rib subluxation are described. The treatments may need to be combined for comprehensive management of first rib dysfunction. Counterstrain techniques for first rib dysfunction have been described in the literature (5, 15) but will not be discussed in detail here due to the need for brevity. Counterstrain techniques are passive, positional techniques used to treat somatic dysfunctions. Counterstrain techniques involve relieving joint pain by passively positioning the involved joint into the position of least pain (5, 15).
Treatment of first rib subluxation should start at the intervertebral joints, then
the structural rib problems, and finally the respiratory restrictions (3). If first rib
dysfunction is secondary to vertebral dysfunction, treatment of the rib alone may
not be sufficient and may lead to recurrence of symptoms (3).

Due to proximity of the first rib to the brachial plexus and subclavian vessels, it is important to handle the first rib gently (3). High velocity (thrust) manipulation techniques of the first rib have been described in the literature (9, 10, 32–34, 36), but nontraumatic controlled techniques are preferred by some
authorities (3, 28). Subluxed joints are hypermobile and should be protected from
forces that may contribute to additional hypermobility (28). There are no
controlled clinical studies that verify the effectiveness of treatment methods
described in this paper.

Osteopathic Muscle Energy Techniques. Muscle energy techniques have
been described for treatment of first rib subluxation (3, 9, 28). These techniques
utilize muscle action and relaxation to mobilize dysfunctional joints. One of the
techniques (9) will be described here (Figure 5). The patient is seated on a table
in front of the therapist. The patient’s neck is bent toward the involved side
without any head rotation (28). The therapist’s fingers are placed lightly on the
supraclavicular fossa of the involved side. The thumb of the treating hand palpates
the posterior aspect of the first rib through the trapezius approximately 6 cm
lateral to the spinous process of T1. Lateral flexion of the neck is performed to
allow relaxation of the scalene muscles, which can be felt with the fingers resting
on the first rib. The patient is asked to bend the neck toward the uninvolved side
with a submaximal contraction while the therapist resists any movement of the
neck or head. This isometric contraction is performed to allow relaxation of the
ipsilateral scalene muscles through reciprocal inhibition.

Muscular relaxation should be felt by the palpating fingers in the supraclavicular
fossa. Once muscle relaxation is felt, the fingers in the supraclavicular

Figure 5 — Muscle energy technique for a right elevated first rib.
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fossa and the thumb can gently guide the rib into its proper position. This is performed by first dislodging the first rib from the transverse process of T1 by guiding it anteriorly and laterally (28). After dislodging the first rib from the transverse process of T1, the rib can be guided inferiorly to its proper position anterior to the transverse process of T1 (28).

Several trials may be necessary for reduction of the first rib. It should also be noted that reciprocal inhibition may not take place if too intense of a contraction is used (28). A powerful contraction of the contralateral neck muscles may lead to contraction of the ipsilateral muscle in an attempt to stabilize the neck (28).

**Joint Mobilization.** Joint mobilization can be useful in treatment of first rib dysfunction. The costovertebral and costotransverse joints of the first rib can be mobilized by direct pressure on the first rib, its costotransverse joint, or the transverse process of T1 (24, 26). McNair and Maitland (26) suggest performing unilateral posteroanterior mobilization of the first rib first and then introducing caudal mobilization.

Positioning for caudal (inferior) mobilization of the first rib is demonstrated in Figure 6. To perform inferior mobilization of the first rib, the patient lies prone and rests the forehead on his/her supinated hands. The therapist stands on the involved side facing the patient’s contralateral hip and palpates the costal arch of the first rib just underneath the upper trapezius muscle. One thumb is placed over the costal arch of the first rib and is reinforced by the other thumb. Interior mobilization of the first rib can be performed by applying pressure through the thumbs and directed toward the opposite hip. The mobilizing force should be generated by the shoulders and elbows, not the intrinsic hand muscles (24, 26). Posteroanterior mobilization of the first rib requires the same positioning; however, the force is directed anteriorly instead of caudally on the transverse process of T1, the first costotransverse joint, or the first rib (26).

![Figure 6 — Caudal mobilization of the right first rib. The force is applied to the first rib just inferior to the trapezius muscle and is directed toward the opposite hip.](image-url)
Either sustained transalatory mobilizations (17) or graded oscillatory mobilizations (24) can be used. Sustained transalatory mobilization grades range from I to III (17). Oscillatory mobilization grades range from I to IV (24). The initial mobilization should be low grade in order to assess the patient’s response. The grade of mobilization to be used is determined from the examination or previous responses to mobilization (10). If the condition worsens after the first session, mobilization may have been too forceful and should be performed at a lower grade. If the condition improves, the previous grade of mobilization or a higher grade might be used.

Therapeutic Exercises. Lindgren and co-workers (19, 22) have studied superior subluxation of the first rib by cineradiography and termed this dysfunction “hypomobility of the first rib” (we will explain the discrepancy in terminology in the Discussion section). They suggest performing isometric contractions of the scalenes to “activate” them and “mobilize” the first rib (19, 22). The patient is instructed to perform isometric neck flexion, ipsilateral sidebending, and extension. The patient offers resistance by pushing his/her head against the palm of the involved side. Each contraction is held for 1 second and is repeated 10 times. The patient is instructed to repeat the exercise 10 times a day. Lindgren et al. (19, 22) claimed that isometric exercises of the scalene muscles led to subjective as well as objective improvement. They reported cases in which symptoms disappeared and cineradiography revealed normal mobility of the first rib. Additionally, the E-I test became negative, indicating normal mobility of the first rib (19, 22). Out of 22 patients who were treated by these exercises, 13 reported complete relief, 3 were improved, and 6 reported no change (19).

Often the scalene, upper trapezius, and sternocleidomastoid muscles are tight or in spasm (8, 10, 13, 32–34). Stretching of these muscles is indicated to prevent recurrence of the subluxation (13, 28, 34). Mitchell et al. (28) have suggested patient education to avoid forward head posture.

Physical Modalities and Immobilization. Physical modalities to control pain and promote muscle relaxation may be beneficial in the management of first rib dysfunction. Use of thermal agents such as heat and cold have been suggested to promote muscle relaxation and decrease muscle spasm (12, 27), and have been advocated as an adjunctive therapy for first rib dysfunction (13). Neuromuscular electrical stimulation (NMES) (13) and transcutaneous electrical nerve stimulation (TENS) can also play a role in treatment of first rib dysfunction. NMES can decrease muscle spasm (16) and TENS application can control pain (12, 16, 35). Soft tissue mobilization techniques to decrease muscle spasm and increase the length of the involved muscles are often indicated (13, 28, 34, 36).

Resting of the first rib joints may be indicated following reduction of the subluxation. Mitchell et al. (28) suggest that the costovertebral ligaments need approximately 2 weeks to heal. They suggest resting the first rib joints and attached muscles by immobilization through the use of collars, slings, or short-term (10–14 days) use of muscle relaxants to allow healing (28). Analgesic agents may also be used to control pain (13).

Discussion and Conclusion

The proximity of the first rib to spinal and sympathetic nerves may explain some of the signs and symptoms observed in first rib dysfunction. Normal biomechanics
and pathomechanics of first rib motion are not clear and further research in this area is indicated. However, the susceptibility of the first rib to sublux superiorly was apparent in the review of the literature (7, 10, 19, 20, 28, 37, 42).

The presence of a cervical rib needs to be ruled out prior to performing any form of manipulation (thrust, mobilization, or muscle energy techniques). Manipulative therapy of a cervical rib is contraindicated because it may harm the patient and aggravate symptoms. Results of any radiographic testing should be requested since cervical ribs may be visible on radiographs. Cervical ribs articulate with the seventh cervical vertebrae (40), and careful palpation and observation may be helpful in identifying their presence.

Lindgren and Leino (19) described superior subluxation of the first rib as “hypomobility of the first rib.” A subluxed first rib may be described as a hypomobile first rib since it is “stuck” in the inspiration position and does not return to the expiration position. Clearly, ROM of a superiorly subluxed first rib will be limited, as has been shown radiographically by Lindgren and co-workers (19, 22). Scalene muscle activation exercises described by Lindgren and Leino (19) have been suggested to operate through activation of the scalene muscles and mobilization of the first rib. The reader is reminded that first rib subluxation is often caused and accompanied by scalene muscle spasm (hyperactivity) (8, 10, 13, 32–34).

We believe that the mechanism through which the isometric exercises proposed by Lindgren et al. (19, 22) operates is of scalene muscle relaxation (through autogenic inhibition) rather than activation. Submaximal isometric exercises have traditionally been used to relax (inhibit) hypertonic muscles (14) and form one of the bases of osteopathic muscle energy (3, 9, 28) and proprioceptive neuromuscular facilitation techniques (39). Lindgren and Leino (19) stated that activation of the scalene muscles will “mobilize” the first rib. They did not explain how a superiorly subluxed first rib could be mobilized by the scalene muscles into an inferior position, given that the pull of all of the scalene muscles is in a superior direction.

To achieve satisfactory results, both the articular and neuromuscular components of first rib dysfunction should be evaluated and treated. In primary first rib dysfunction, reduction of first rib subluxation may not be sufficient if muscular imbalances continue to be present. Scalene, upper trapezius, levator scapulae, or pectoral muscle tightness should be treated, if present. Neglect of such muscular imbalances may predispose one to recurrence of symptoms. Similarly, treatment of the muscular component and neglect of the articular dysfunction will lead to recurrence of symptoms. In secondary first rib dysfunction, the primary intervertebral lesion should be sought and treated. Special attention should be paid to the upper and lower cervical spine (C-spine). Dysfunction of the craniovertebral and cervicothoracic regions often is accompanied by forward head posture. The forward head posture components are excessive flexion at the lower C-spine and compensatory extension at the upper C-spine. With forward head posture, tightness of the suboccipital muscles should be suspected and, if present, treated.

It is evident that primary as well as secondary first rib subluxation is initiated by undue contraction of the scalene muscles (8, 10, 13, 32–34) (Figure 7). In primary first rib subluxation, contraction of the scalenes is performed to stabilize the neck while performing a sudden powerful arm movement. This
usually is a unilateral powerful contraction of the scalene muscles with resultant superior subluxation of the first rib. Primary first rib subluxation may occur following a slip, misstep, or a fall in which the arm is extended to break an anticipated fall (32, 33). Primary first rib subluxation may occur in wrestling or while planting a pole in the pole vault. Athletes without proper training or supervision could develop a primary first rib subluxation during weight training. In secondary first rib subluxation, contraction of the scalenes is secondary to other problems (see Figure 7). This contraction would be best described as muscle spasm. Possible reasons for development of muscle spasm are outlined in Figure 7 (14).

First rib dysfunction may go undetected if careful examination is not performed (10, 13, 37). Due to concurrent presence of marked muscle spasm and tenderness in the upper trapezius muscle, first rib dysfunction may be misdiagnosed as upper trapezius “strain.” It has been reported that “myositis” of the upper trapezius is often accompanied by first and second rib dysfunction (38). Since pain arising from first rib subluxation may be referred to the deltoid area, it can be incorrectly diagnosed as subdeltoid bursitis (13).

Further studies are needed in order to explain normal biomechanics and pathomechanics of the first rib. Controlled studies are also needed to verify the reliability and validity of clinical tests used for diagnosis of first rib subluxation. In addition, controlled clinical studies are needed to verify the effectiveness of treatment methods described in this paper.

In conclusion, first rib dysfunction may be the cause of acute or chronic neck, shoulder, and arm pain. It may be a primary lesion or secondary to vertebral joint dysfunction. First rib dysfunction should be suspected and included in the differential diagnosis of neck, shoulder, and arm pain.
Subluxation of the First Rib

References


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