Evaluation & Treatment of Thoracic Outlet Syndrome

Thoracic Outlet Syndrome

The term TOS states where the problem is, but not what the problem is!

Not every TOS problem is the same

Other names for TOS:

- Cervical Rib Syndrome
- Costoclavicular syndrome
- Scalenus anticus syndrome
- Hyperabduction syndrome
- Pectoralis minor syndrome
- Adson’s syndrome
- Brachial plexus syndrome
- Shoulder arm syndrome

A careful history and thorough physical examination are the most important components in establishing the diagnosis of TOS.


Where is the Thoracic Outlet?

Bony anatomy:
- Clavicle
- 1st Rib
- Scapula

Path of the Brachial Plexus...

Travels through 3 main passageways...
- scalene triangle
- costoclavicular space
- thoraco-coraco-pectoral gate

These passageways are narrow and dynamic with movement!
**Brachial Plexus Gates**

1st passageway:
- **Scalenus Triangle**
  - Between the anterior and middle scalene muscles

2nd passageway:
- **Costoclavicular space**
  - Between the clavicle and 1st rib

3rd Passageway:
- Beneath the pectoralis minor muscle

**The Big Issue:**
- Patient's present with varying signs and symptoms
- Long duration of symptoms
- Sometimes difficult to find a pattern
  - = Mystery

**TOS: Symptoms**

Common Clinical Presentations of TOS
- Numbness/tingling in the ring and small finger; but can encompass entire hand and forearm
- Parasthesias occur at night and/or during daily activities
- Vague, pain in the involved extremity, can occur in the hand, elbow, shoulder and/or cervical spine
- Subjective complaints of hand/arm weakness, especially with arm raised overhead
- Subjective complaints of swelling in the absence of true swelling

**History**

Symptoms reported:
- Paresthesia in the upper limb (98%)
- Neck pain (88%)
- Trapezius pain (92%)
- Shoulder and/or arm pain (88%)
- Supraclavicular pain (76%)
- Chest pain (72%)
- Occipital headache (76%)
- Paresthesias in all 5 fingers (58%)
- Paresthesias in 4th-5th fingers only (26%)
- Paresthesias in 1st-3rd fingers only (14%)

Hooper et al. Thoracic outlet syndrome: a controversial clinical condition. Part I: anatomy and
Evaluation & Treatment of Thoracic Outlet Syndrome

2 Groups of Physicians:

- Based on objective findings
  - Based on imaging, vascular tests, and electrical studies
- Based on clinical findings
  - Reproduction of symptoms with provocative maneuvers

Two Categories of TOS

<table>
<thead>
<tr>
<th>Vascular (vTOS)</th>
<th>Neurogenic (nTOS)</th>
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<tr>
<td>-2% of total TOS</td>
<td>-98%</td>
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<tr>
<td>- Usually caused by structural lesion</td>
<td>- Responds to therapy (conservative care)</td>
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<td>- Easier to define, diagnose and treat then nTOS.</td>
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Vascular TOS: 2 types

- Arterial TOS
  - Young adults hx of vigorous arm activity
- Venous TOS

TOS: Neurogenic: 2 types

- True neurogenic TOS
  - Sensory symptoms
  - Hand weakness
  - Muscle wasting
  - Cervical rib present
  - EMG: axon loss (true axonal compression)
- Disputed neurogenic TOS
  - “The ore in the great thoracic mine”

Disputed Neurogenic TOS

- Most common cause: traction
  - Negative imaging
  - Negative vascular tests
  - Electrical studies: of little value
  - Pain, parasthesias are the first sign
  - Traction is intermittent

Clinical profile and diagnosis of TOS - SUMMARY

Compressors
- patients complain of symptoms when performing overhead activities
- do not typically awake at night from paresthesias, unless arm is overhead
- occupation usually involves overhead work

Releasers
- patients experience symptoms primarily at night
- occupation involves more sedentary-type of work
- these patients tend to have large, heavy arms and poor posture

Roos Test/Elevated Arm Stress Test (EAST)
Criteria:
- Pain and/or sensory changes in the brachial plexus distribution
- Aggravation of pain with use of the affected extremity

Roos Test/Elevated Arm Stress Test (EAST)
- Technique: therapist places a downward pressure on the scapula, while patient opens and closes hands.
- Positive test: reproduces patient’s symptoms within 90 seconds.
- Document: the amount of time needed to reproduce patient’s symptoms and the location/nerve distribution.

TOS: Clinical Examination

TOS: Compressors
- When the patient raises the arm overhead, the brachial plexus makes a “U-shaped” turn over the 1st rib, then under the clavicle (costoclavicular space)
- The compression is intermittent: the blood supply to the nerve returns when the patient lowers their arm

TOS: Compressors
- during daily activities, the brachial plexus is being pulled down
- when a nerve is very slightly stretched (8% beyond its normal, resting length) venous pooling occurs around the nerve
- this inhibits blood flow to the peripheral nerves

TOS: Release Phenomenon
- In sitting and standing, the nerves are under tension, due to the effects of gravity
- When the person goes to bed, the tension on the nerves is gradually released

Criteria:
- Pain and/or sensory changes in the brachial plexus distribution
- Aggravation of pain with use of the affected extremity


At the moment the normal function returns, (typically with sleeping at night), the axons fire and patient’s experience paresthesias.


Cyriax Release Test (CRT)

Purpose of the CRT: To directly unweight the arms, allowing blood flow to return to the peripheral nerves at a rapid pace. Essentially, the therapist is “opening the dam” to allow blood flow to the blood-starved extremities!


Positive test: reproduces patient’s symptoms within 90 seconds. Document: time needed to reproduce symptoms and location/nerve distribution & time of day test was performed.

Alternate position!


Role of the Scalene Muscles

• When the scapular muscles are weak, the scalene muscles can often become “overworked”.
• These muscles are responsible for elevating the first rib (occurs more with compressors, but can also be seen with releasers).

Changes in the Scalene Muscles...

- A history of a MVA can also contribute to increased tonicity of the scalenes
- Sanders found atrophy of Type II muscles fibers, predominance of Type I fibers, and a 25% increase in connective tissue in the scalene muscles following a MVA


Where is the 1st rib?

1st rib:
- Connects to the transverse process and vertebral body of T1
- Travels just inferior to the medial 1/3 of the clavicle

Cervical Rotation Lateral Flexion Test (Lindgren Test)


TOS: 1st rib

An elevated 1st rib can contribute to brachial plexus problems at the

1st passageway: Scalene triangle
and
2nd passageway: Costoclavicular Space

TOS: 1st rib

Can occur with both compressors and releasers

** must have at least 20° of cervical sidebending to perform this test!


Technique: using your elbows to block trunk rotation, passively rotate the cervical spine to end-range, then perform contralateral sidebending (i.e. drop ear to sternum)

So why is posture so important?

- Poor scapular positioning at rest and/or with activity can contribute to TOS

**TOS: scapular alignment & stability**

**Scapular depression**

- Investigated the hypothesis that the lower position of the shoulder girdle relative to the upper thorax may be related to neurogenic TOS (nTOS)
- Using plain radiographs, analyzed the number of vertebrae visible above the level of the clavicle on lateral radiograph & above the line connecting the sternal ends of the clavicle on AP radiographs


**Results**: both parameters were greater in the nTOS group, suggesting the level of the shoulder girdle was lower in the nTOS versus controls

**Conclusion**: the lower placement of the shoulder girdle relative to the upper thorax was related to nTOS

Physicians may be able to estimate the position of the shoulder girdle using plain cervical radiographs when nTOS is suspected

**TOS: scapular alignment & stability**

**Scapular depression neurodynamic testing**

- Aim of study: to determine if there was a meaningful difference in test outcomes when the upper limb neurodynamic test (ULNT) was performed in alternative scapular positions
- **Results**: pre-positioning the scapula in depression led to reduced elbow extension ROM, provoked greater upper trap activity activity, and an earlier onset of sensory responses
- **Conclusion**: scapular positioning has a meaningful impact on ULNT in healthy, asymptomatic individuals


Scapulothoracic instability (at rest and/or with activity) can contribute to brachial plexus problems at the 2nd passageway: costoclavicular space

3rd passageway: beneath pect minor

Key element: subjective history

- Was this a gradual onset (more common) or acute?
- Does the patient have a history of other “seemingly unrelated” upper extremity problems?
- Typically, the patient will lead you to the diagnosis before you even touch them

Key element: subjective history

- Does the patient awake with symptoms at night? – Think releaser
- Does the patient have more symptoms when they reach overhead? – Think compressor
- Has the patient been involved in a MVA? – Consider scalene hypertrophy

Cervical Screen

* extend “look up” (with mouth open, to achieve full extension ROM)

* ask patient to perform forward flexion “bring your chin to your chest”

Purpose: to rule out pain coming from a cervical origin: disc or nerve root pathology

Cervical Screen

* rotate: “look to the right and left”

* side-bend: “bring your ear to your shoulder”

Cervical Screen

**Spurling’s test**

- Patient performs cervical extension with ipsilateral sidebending & rotation
- Apply gentle downward pressure on patient’s head to provide compression
- Perform on each side
- Positive test: reproduction of patient’s symptoms in a dermatomal pattern

Cervical Spine Screen

If any of these cervical motions reproduces the patient’s symptoms

Game Over

This is not a thoracic outlet problem!!!
**2 Provocative Tests for TOS**

- **Cyriax Release Test**
  - Is the patient a Releaser?

- **Elevated Arm Stress Test**
  - Is the patient a Compressor?

**Cyriax Release Test**

Technique: Passively elevate the shoulder girdle, unweighting arms, to provoke increased blood flow to brachial plexus & upper extremities


**Elevated Arm Stress Test (EAST)**

- Technique: therapist places a downward pressure on the scapula, while patient opens and closes hands.
- Positive test: reproduces patient’s symptoms within 90 seconds.
- Document: the amount of time needed to reproduce patient’s symptoms and the location/nerve distribution.


**Double Crush in Cyclists…**

- Clinically + ulnar nerve symptoms, 32%: + Roos (EAST)
  - 43%: + Cyriax Release test

- Conclusion: a significantly greater number of upper limbs with clinical signs & symptoms of ulnar nerve neuropathy presented with signs indicative of proximal TOS dysfunction, suggestive of double crush syndrome


**Posture: Assessing Scapular Position at rest**

Scapular positions that can most contribute to TOS:

- Depression
- Downward Rotation
- Winging or Tilting

Scapular Depression
- With overhead reaching, deep creases are observed at the AC joints
- Associated with large, heavy arms
- This pattern seen commonly with Releasers

Scapular Depression
- Are there deep creases at the AC joints with end-range motion?
- Are there complaints of parasthesias as the arms are raised overhead?
- Do the arms suddenly “feel heavy” with maintaining the overhead position?

Scapular Downward Rotation
- Inferior angle of scapula closer to spine than superior angle
- Tend to have large, heavy arms
- Associated with Releasers

Scapular Downward Rotation
- Does the inferior angle of the scapula reach the mid-axillary line?
- Are there complaints of parasthesias with overhead reaching?
- Are there complaints of “pulling” or pain in the teres major/lattissimus dorsi region?

Scapular Tipping or Winging
- Muscle length impairments:
  1. Short pect major and pect minor muscles
  2. Long lower trap: scapular tipping
  3. Weak or long serratus anterior: scapular winging

Assessing the Elevation Chain...
- Shoulder (Glenohumeral joint)
- Acromioclavicular joint (ACJ)
- Sternoclavicular joint (SCJ)
- Thoracic spine

Joint stiffness or capsular tightness can contribute to compression of the brachial plexus in the thoracic outlet
Posterior Capsular Tightness at the Glenohumeral Joint

**Posterior-superior:**
- Can limit ability to reach behind back
- Tested in a standing position

**Posterior-Inferior:**
- Can limit shoulder internal rotation (IR) in an abducted position
- Tested in supine or standing

Testing for Posterior-Superior Capsular Tightness

- Patient stands with arms relaxed
- Therapist brings arm behind back (achieving full shoulder adduction), then gently pulls forearm off patient’s low back—into further IR

Testing for Posterior-Inferior Capsular Tightness

- Patient is in standing or lies in supine, with shoulder in abduction
- While maintaining scapular stabilization, then passive internal rotation is assessed

Passive Elevation Test

**Part I:** contralateral scapular stabilization

- The therapist stabilizes the superior aspect of opposite scapula

**Part II:** ipsilateral scapular stabilization

- The therapist stabilizes the scapula on the same side (not allowing contribution from the AC & SC joints)

A firm end-feel indicates a limitation may be present at either the GH, SC, or AC joints
A firm end-feel indicates a limitation may be present at the GH joint.

Passive Elevation Test

**Part II:** ipsilateral scapular stabilization

Orientation of the GH Joint

In a standing position  
At end-range

End-range GH Joint testing

- **Anterior:** toward patient’s chin
- **Inferior:** perpendicular to a line from the patient’s chin to the posterior acromion
- **Posterior:** toward the posterior acromion

SC & AC Joint testing

- **SCI:** Inferior glide
- **ACI:** Anterior glide

Importance of Mobility at the Cervico-Thoracic Junction

Norlander found: 381 workers, reduced mobility at the CT junction significantly predicted neck-shoulder pain and weakness in hands

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TREATMENT STRATEGIES

Soft Tissue Techniques...

- **Scalenes**

- **Pectoralis Minor**

Soft Tissue Techniques...

Mobilizing the 1st rib...

- **Costotransverse joint** controls the lateral translation of the rib cage
- **Costovertebral joint**: controls the rotation (resembles the motion of a bucket handle)

Mobilizing the 1st rib

- **Costotransverse joint**
  - Should always be mobilized first (as it will assist in mobilizing the costovertebral joint)
  - 40 second holds for 2 repetitions

- **Costovertebral joint**
  - The key is to maintain pressure on the rib with the patient exhaling; this pressure is maintained with the 2nd deep breath
  - 40 second holds for 2 repetitions

Mobilizing the 1st rib: CTJ

- **Costotransverse Joint**: mobilize in a *ventral-lateral* direction

(Patient performs relaxed breathing)
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1\textsuperscript{st} rib: CTJ Mobilization

Mobilizing the 2\textsuperscript{nd} rib

- Costovertebral joint is mobilized anteriorly (with the patient in supine)
- Costotransverse joint is mobilized posteriorly (with the patient in prone)

1\textsuperscript{st} rib: CVJ Mobilization

2\textsuperscript{nd} rib: CVJ Mobilization

Home program: Scalene stretch

Common Errors with Performing the Scalene Stretch

- Strap placement: the strap is placed over the superior aspect of the shoulder (verses 1\textsuperscript{st} rib), and patient exacerbates symptoms with scapular depression
- Too aggressive with chin tuck and side-bending—placing excessive tension on the brachial plexus at the scalene triangle
- The patient utilizes the involved hand to pull down on the strap, exacerbating symptoms
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**Purpose:** To maximize blood flow to the upper extremities by releasing the tension on the brachial plexus. This will promote improved sleep at night!

**Release Maneuver**

**Neural Flossing Techniques**

- **Purpose:** to gently increase movement of the nerve and its surrounding connective tissue to improve blood flow and nutrition to the nerve using active-assistive ROM
- **These “flossing” or gliding techniques should not be painful. Patients may report some mild “pulling” along the peripheral nerve distribution.**


**Neural Flossing Techniques**

**Ulnar Nerve: Distal (early stage)**


**Ulnar Nerve: Proximal (later stage)**


...care should be taken to monitor pain, paresthesia, and protective reflexes that may signal the limit of the tolerance of the nerve to tensile stress.
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**Neural Flossing Techniques**

**Median Nerve: Distal (early stage)**  

Note: the thumb stays in a relaxed position!

**Median Nerve: Proximal (later stage)**  

**Radial Nerve: Distal (early stage)**  

Note: the index and middle fingers stay in a relaxed position!

**Radial Nerve: Proximal (later stage)**  

**Addressing Scapular Alignment**

- Bra straps can place a significant amount of downward pressure on the acromial end of the scapula (causing increased depression or downward rotation of the scapula)
- Recommending bras that have a racer back, t-strap, or crisscross design can help unload the shoulders to achieve improved positioning with daily activities!

**Scapular Winging: Home Exercise Program Ideas!**

- Supine SA “punching”
- “Dynamic hug” with theraband
- Scapular taping to encourage upward rotation of the scapula at rest
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**Serratus Anterior Punching**

**Dynamic Hug**

**Taping to encourage Scapular Upward Rotation**

**Scapular Tipping: Home Exercise Program Ideas!**
- Towel roll between scapula (in supine) to increase pect minor length
- PNF D₂ patterns
- Scapular taping to encourage upward rotation of the scapula at rest

**Pect minor stretch on foam roll**
- **Pectoralis minor stretch**
  - Patient lies on a rolled towel or pool noodle/foam roll while gravity assists with pectoralis minor stretch.
  - Stretch can be intensified with addition of active scapular retraction.

**PNF D2 patterns**
- Start in supine and progress to standing
- This will strengthen the lower trapezius, thereby improving posterior scapular stabilization
- Avoid any impingement symptoms!
### Scapular Depression
#### Home Exercise Program Ideas!
- Wall slides (shoulder shrugs)
- Prayer stretch
- Scapular taping in an “X” to encourage scapular elevation at rest

#### Wall Slides (Shoulder Shrugs)
The patient is instructed to “lead” with the scapula

### Scapular Downward Rotation
#### Home Exercise Program Ideas!
- Encourage serratus anterior recruitment!
  - Punching in supine, dynamic hug, wall push-ups
  - Scapular taping to encourage upward rotation of scapula at rest
  - Figure-8 strap can also be helpful

#### Taping to improve scapular retraction/elevation

#### Figure-8 can also be helpful to promote scapular retraction

#### Encourage Serratus Anterior recruitment for upward rotation
Taping to encourage Scapular Upward Rotation

Ergonomic considerations

Recommendations
- Lowering chair to allow arms to be supported on desktop
- Split keyboard
- Vertical mouse

Testing for Posterior-Superior Capsular Tightness

- Patient stands with arms relaxed
- Therapist brings arm behind back (achieving full shoulder adduction) then gently pulls forearm off patient’s low back—into further IR

Mobilizing the Posterior-Superior capsule

Home Program Ideas

Doorframe Stretch (for post-superior capsular tightness)
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**Home Program Ideas**

**Passing a weighted ball behind back**
- Be sure patient is maintaining scapular stabilization (avoiding anterior tilting!)

**Testing for Posterior-Inferior Capsular Tightness**
- Patient is in standing or lies in supine, with shoulder in abduction
- While maintaining scapular stabilization, then passive internal rotation is assessed

**Mobilizing the Posterior-Inferior capsule**

**Sleeper Stretch**
(for post-inferior capsular tightness)

**End-range GH Joint testing**
- Anterior: toward patient’s chin
- Inferior: perpendicular to a line from the patient’s chin to the posterior acromion
- Posterior: toward the posterior acromion

**Posterior-superior and Posterior-inferior capsular tightness at the Glenohumeral joint...**
- Can limit brachial plexus gliding at the 3rd passageway: beneath the pect minor muscle
- Can occur with poor scapular stabilizer muscle control
End-range GH treatment

- Anterior Glide

End-range GH treatment

- Superior Scapular glide (Inferior glide)

Address the AC and SC joints, based on findings from the Passive Elevation test!

- Acromioclavicular joint (AC joint)
- Sternoclavicular joint (SC joint)

SC & AC Joint treatment

- SCI: inferior glide
- SCI: curved glide

SC & AC Joint treatment

- ACJ: anterior glide
- ACJ: curved glide
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Once the GH, SC, and AC Joint mobility is restored...

- It’s time to address the cervical-thoracic junction!
- Improving extension from T1-T6 can assist in achieving end-range shoulder elevation to eliminate brachial plexus irritation with compressors

Joint Specific Techniques for the Cervico-thoracic Junction

- Improving dorsal-ventral segmental mobility can facilitate thoracic extension and end-range elevation

Dorsal-ventral glides to T1-T6

- This is performed in an oscillatory fashion, starting from T1 to T6
- Move down one level each time the patient’s trunk is passively brought into extension

Chronic Pain...

- Over the past 10 years, there has been an increasing amount of research and literature describing the mechanism of chronic pain
- In the past, these patients used to be told “it’s all in their head”
- Now, new research shows chronic pain is a complex occurrence that changes the body’s sensitivity to stimuli which can cause “everything to hurt”!

What if everything hurts?

Some important considerations with chronic pain.....

2 Response Systems in the Body

Sympathetic System “fight or flight”
- Designed to be on/off
- Releases adrenaline into the body
- Adrenaline in the body long-term can cause pain magnification

Parasympathetic System “rest and digest”
- Concerned with conserving energy
- Aids in digestion, storing energy and cellular replenishment
- “Calming state”: more active during sleep

The Sympathetic System

Increased Sympathetic Activity can cause…
Vasoconstriction: leading to a sympathetic-mediated ischemia causing
- Slowed healing
- Increased risk of double crush
- pH changes ("acid tissues") causing increased mechanical sensitivity

When pain becomes chronic…

- Persistent pain can contribute to sleeplessness
- Not enough sleep = not enough ongoing repair of tissues
- Due to the heightened state of the sympathetic system, the parasympathetic system needs to be activated!

What can we, as therapists, do for these patients?

- Explain what’s going on---this is NOT all in their head!
- Give the patient some control—useful tools to help increase the parasympathetic system
- Inhibit the sympathetic nervous system

Describe and explain the chronic pain cycle…

- David Butler, PT, advises to sit down with the patient and explain this pain cycle
- Knowledge is power!
- This will help the patient to understand there is not something terribly wrong with them!

Let’s review...

Therapy Management

- Educate the patient in proper positioning with daily activities to encourage optimal posture, including ergonomic considerations
- Strengthen the scapular stabilizers to assist in appropriate scapular alignment
- Promote blood flow to the peripheral nerves through general exercise and performing neural flossing techniques.
- Restore appropriate joint mobility at the 1st and 2nd ribs, shoulder (Glenohumeral joint, AC and SC joints), and cervical-thoracic junction
Timeframes for Conservative Treatment

- Typically takes at 4-6 weeks of treatment to see improvements
- 12-14 weeks for significant functional improvements
- Functional improvements are likened to the stock market: there are small ups and downs, but a general progression up (before 2008)

Patients must continue with their home exercise program after formal therapy is completed, or they may have some return of their symptoms.

Thank you!

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