

# Thoracic Outlet Syndrome, Part 1: New proposed classification system

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## Background

The term Thoracic Outlet Syndrome (TOS) was first introduced in 1956 (Peet 1956). Following decades of clinical research, its diagnosis and classification continues to lack standardization and there remains ongoing debate regarding its ideal management (Munro et al 2016). The prevalence of TOS continues to be very controversial with strong opinions at both ends of the spectrum where some have claimed it is over-diagnosed (Wilbourn 1990, Munro et al 2016) while others claim it is under-diagnosed (Roos 1990, Selmonosky 2008).

The term TOS is currently defined as “*upper extremity symptoms due to compression of the neurovascular bundle in the area of the neck just above the first rib*” (Sanders et al 2007).

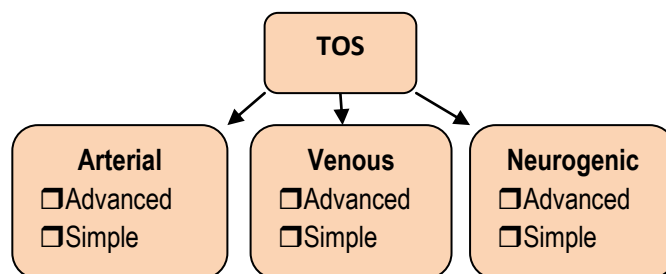


The thoracic outlet can become compressed through hypertrophy of the scalene muscles from repetitive motion or as a result of congenital cervical or anomalous ribs (Tam et al 2016). Details on the pathoanatomy and epidemiology of TOS have been well described in other papers (Hooper et al 2010, Munro et al 2016) and are therefore not the objective on this paper. The intention of this paper is to assist clinicians to identify and classify TOS more confidently; this novel classification approach is based on relatively simple clinical tests. It is suggested that earlier identification and specific management of TOS

may prevent the progression of this sometimes debilitating condition.

## Classifying TOS

There are three primary classifications of TOS: arterial, venous and neurogenic. They affect 1%, 4% and 95% of patients with TOS respectively (Sanders et al 2007). The three classifications are not mutually exclusive as a mixed neurovascular syndrome is often present (Likes et al 2014), however classifying TOS in one of the three classifications based on the symptoms that predominate is suggested.



The TOS classification can further be divided into “Advanced” or “Simple”. “Advanced”, which is also referred to as “complicated” TOS is relatively easy to identify and diagnose as patients will present with obvious and severe neurovascular signs and symptoms. There is little controversy in identifying “Advanced” TOS as the diagnosis can be confirmed with objective medical investigations. On the other hand “Simple” or “uncomplicated” TOS symptoms are more subtle and objective medical investigations are inconclusive.

**Advanced Arterial TOS** related to compression of the subclavian artery can be diagnosed when patients present with obvious, constant and severe global discoloration, ischemia, numbness and coldness of the hand. Patients with Advanced Arterial TOS are unlikely to report of any relieving postures or positions and will have positive vascular imaging tests (Sanders et al 2007). Alternatively **Simple Arterial TOS** can be considered when patients report of mild to moderate, intermittent hand discoloration, numbness and coldness. They will report of specific relieving and aggravating postures and positions. Vascular imaging tests are not indicated for this TOS population as they will likely be negative.

**Advanced Venous TOS** related to compression of the subclavian vein can be diagnosed when patients report of a **constant** heaviness feeling in the arm irrespective of usage. They will also report of deep chest pain with referral into the entire upper extremity. Patients with Advanced Venous TOS will also have positive vascular imaging tests (Sanders et al 2007). Alternatively **Simple Venous TOS** can be considered when patients report of a mild to moderate, **intermittent** heaviness feeling in the arm aggravated by usage and relieved by rest or specific postures and positions.



**Advanced Neurogenic TOS** can be diagnosed when patients present with significant neck, anterior chest wall and shoulder pain in addition to weakness, paraesthesia and atrophy of the hypothenar eminence of the hand. Patients with Advanced Neurogenic TOS will have positive nerve velocity conduction and electromyography

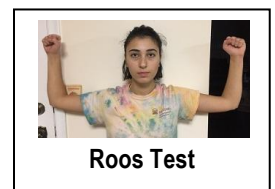
(EMG) tests. These patients are often unresponsive to conservative management strategies and will require pharmacological management of the neural symptoms and a surgical consultation (Mackinnon et al 2002, Munro et al 2016).

Fortunately, Advanced Neurogenic TOS is uncommon as the vast majority of patients present with **Simple Neurogenic TOS**, reporting intermittent and fluctuating neck, shoulder and thoracic pain in conjunction with fifth and fourth digit paraesthesia. They will not present with atrophy of the hypothenar eminence of the hand. Simple Neurogenic TOS may be present in individuals with whiplash associated neck pain and those involved in occupations or hobbies involving sustained slouched postures such as secretaries, dentists or musicians. Patients with Simple Neurogenic TOS will have normal nerve conduction velocity and EMG tests. Simple Neurogenic TOS is best managed conservatively with focus on postural modification, specific exercises and manual therapies (to be discussed in part 2 of this paper).

### Traditional Tests for Identifying Arterial & Venous TOS

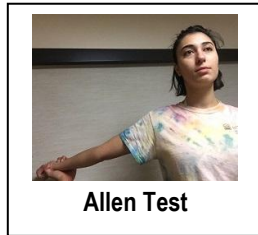
The five traditional clinical tests suggested for identifying TOS include the Roos, Allen, and Adson's tests, the costoclavicular maneuver and the white hand sign.

The **Roos test** is performed with the arms abducted to 90° in the coronal plane with the forearms vertical and palms forward; the patient is to clench and unclench their fists for up to 3 minutes. The test is considered positive for



TOS if the patient's hand symptoms or fatigue of the arm is reproduced (Roos 1990).

The **Allen test** is considered positive when the radial pulse is reduced during extreme horizontal abduction of the arm (Vu-Rose et al 1997).



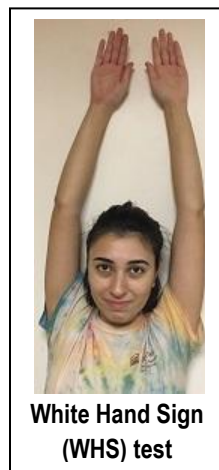
The **Adson's test** is considered positive when the radial pulse is reduced during cervical extension, ipsi-lateral or contra-lateral rotation while the patient is instructed to sit up tall and take in a deep breath (Gillard et al 2002).



The **costo-clavicular maneuver** is considered positive when upper extremity symptoms are reproduced while the patient maintains an exaggerated military posture with the shoulders back and downward (Gillard et al 2002).



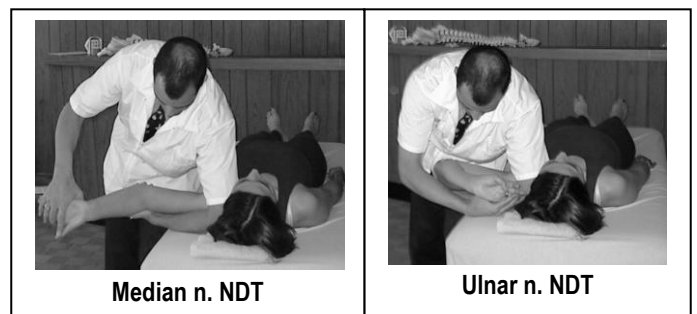
**White hand sign (WHS)** is assessed by observing the patient's hand colour when the arms are elevated over the head with the fingers pointed to the ceiling and the palms facing the observer. A positive test is the appearance of paleness on one or both hands after holding this position for 10 seconds (Selmonosky et al 1981).



Although commonly described in literature and medical textbooks, the validity of the previously mentioned TOS clinical tests has been questioned; Roos, Allen and Adson's tests have been shown to be invalid, contributing to misdiagnosis of TOS as they can be negative in those with TOS and positive in asymptomatic individuals (Sanders et al 2007, Munro et al 2016). Considering the fact that the five traditional TOS tests rely primarily on vascular signs, they may in fact be valid for only 5% of the TOS population presenting with Arterial or Venous TOS. Therefore the vast majority of patients presenting with potential Neurogenic TOS may require alternative diagnostic clinical tests.

### Clinical Tests for Identifying Neurogenic TOS

Median nerve and ulnar nerve **neurodynamic testing (NDT)** have been shown to be reliable and valid for identifying cervical radiculopathies and excellent for screening for sensitization of the neural tissue in the cervical spine, brachial plexus and upper limb (Wainner et al 2003). NDT tests are not specific for detecting neural sensitization in one area, for instance, a positive ulnar nerve NDT may indicate nerve sensitization or compression at the nerve root in the cervical spine, the thoracic outlet, the ulnar groove at the elbow, or tunnel of Guyon at the wrist. Although there are no studies to date supporting the validity of NDT specifically for TOS, it may nevertheless be an excellent



screening test; if NDT is negative, Neurogenic TOS may be ruled out. If positive, further clinical testing specific for Neurogenic TOS is warranted.

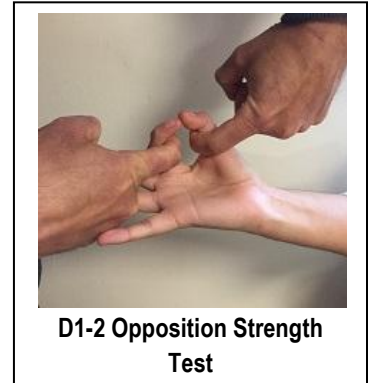
**The relative weakness of the fifth finger test (RWFF)** has been suggested to be another hallmark for TOS (Selmonosky et al 2008). The RWFF test is performed by attempting to separate the patient's opposing thumb and fifth finger (D5) and the separation force is applied by the examiners hooked index fingers. Initially the opposition strength of the thumb and the fifth finger of the non-affected hand is evaluated and immediately compared to the symptomatic upper extremity. RWFF can be classified as either positive or negative. RWFF test is considered negative if no relative weakness is identified where no difference between fifth finger opposition strengths of the two hands is noted.

The RTWFF test is considered positive if the examiner is able to separate thumb and fifth finger opposition with relative ease on the symptomatic upper extremity. A patient with a positive test can be further classified as having mild, moderate or severe C8-T1 myotomal weakness.

The strength of the thumb and the second finger opposition involves muscles innervated by the median nerve: flexor digitorum superficialis and profundus, opponens pollicis brevis, and flexor pollicis brevis. When weakness of the opposition of the thumb and the second finger is present, it



may be an indication of C6-7 radiculopathy or advanced carpal tunnel syndrome. A positive test and visible thenar eminence atrophy, justifies referral for nerve conduction test.



The opposition of the thumb and the fifth finger involves primarily muscles innervated by the ulnar nerve: palmar interossei, opponens digiti minimi, and flexor digiti minimi. When weakness of the opposition of the thumb and the fifth finger is present, it may be an indication of C8-T1 radiculopathy, TOS, ulnar compression neuropathy at the elbow or the wrist (Guyon's).

The RWFF test may be performed on all patients complaining of neck and upper extremity symptoms to potentially identify C8-T1 involvement and perhaps TOS based on other concurrent findings.

### Clinical Tests for Identifying 1<sup>st</sup> Rib dysfunction and Scaleni over-activity

**Supraclavicular tenderness** is evaluated by applying pressure over the ipsilateral supraclavicular area, lateral to the sternocleidomastoid muscle just above the clavicle. Exquisite tenderness in the region may indicate irritation of the brachial plexus.

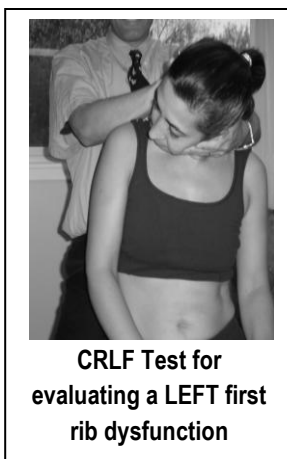




Based on Selmonosky et al (2008), supraclavicular tenderness, RWFF and white hand sign tests are referred to as the diagnostic triad and if all three are positive, the diagnosis of TOS is almost certain.

### The **cervical rotation lateral flexion (CRLF)**

test has been shown to have good reliability and validity for detecting individuals with TOS based on the hypothesis that the test can detect a restricted first rib (Gilbert et al 2004, Lindgren et al 1992). With the patient seated, the examiner passively rotates the head away from the affected side and slowly flexes the neck forward to end range moving the ear toward the sternum. The CRLF test is considered positive if the forward flexion part of the test is markedly decreased with a hard end feel. The hard end feel is hypothesized to be due to the 1<sup>st</sup> rib blocking the C7 transverse process (Lindfren et al 1990).



Although there is no study to date to support this hypothesis, the CRLF test may help detect an abnormal or a cervical rib. The incidence of cervical ribs and abnormal first ribs is less than 1% in the general population and, despite popular assumption, not associated with non-traumatic TOS. The incidence of cervical rib or abnormal first rib was less than 5% of those with Advanced/complicated TOS who underwent surgery (Sanders et al 2008).

### **Further Investigations:**

If following clinical examination, Advanced/complicated TOS is suspected, further confirmatory imaging tests are warranted. The American College of Radiology recommends confirmation of Advanced TOS using arterial and venous duplex ultrasound of the neck and upper extremity in addition to chest radiography to assess for cervical ribs (Tam et al 2016). Sensitivity and specificity of MRI in diagnosing TOS are low and therefore not recommended (Singh et al 2014).

### **Summary**

The aim of this paper was to review a new classification system for diagnosing Advanced or Simple arterial, venous and neurogenic TOS. Several identifying clinical presentations and clinical tests for identifying TOS were discussed. It is hypothesized that earlier identification and management of simple TOS may help prevent progression of symptoms of this sometimes debilitating condition. Further research investigating the reliability of this classification system is warranted to help improve standardization of diagnosis and treatment of this currently controversial condition.

Part two of this paper will discuss twelve specific management options for patients presenting with signs and symptoms of TOS.

	Simple Neurogenic TOS	Advanced Neurogenic TOS	Simple Venous / Arterial TOS	Advanced Venous TOS	Advanced Arterial TOS
Neck & shoulder pain	✓	✓	✗	✗	✗
Occipital headaches	±✓	±✓	✗	✗	✗
Anterior chest pain	±✓	±✓	✗	✓	✗
Edema of arm	✗	✗	±✓	✓	✗
Hand discoloration / White Hand Sign (WHS)	✗	✗	±✓	✓	✓
Global hand numbness & coldness	✗	✗	±✓	✗	✓
Feeling of arm heaviness	✗	✗	±✓	✓	✗
Specific D4-5 numbness	✓	✓	✗	✗	✗
Relative weakness of fifth finger (RWFF)	±✓	✓	✗	✗	✗
Supraclavicular tenderness	✓	✓	±✓	✓	✓
Ulnar & Median n. NDT	✓	✓	✗	✗	✗
Cervical Rotation Lateral Flexion Test (for 1 <sup>st</sup> rib dysfunction)	±✓	±✓	±✓	±✓	±✓
Roos, Allen, Adson's and Costoclavicular Maneuver tests	✗	✗	±✓	±✓	±✓
Doppler ultrasound / Agniography	✗	✗	✗	✗	✓
Venous ultrasound / Venography	✗	✗	✗	✓	✗
Nerve conduction studies	✗	✓	✗	✗	✗
<b>Proposed management Strategy</b>	Conservative	Conservative ± Surgery	Conservative	Surgery	Surgery

Table 1: Summary of TOS classification and associated signs & symptoms

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