CRITICALLY APPRAISED TOPIC

FOCUSED CLINICAL QUESTION

In people with symptoms involving the thoracic spine are nerve conduction velocities or shoulder special tests (Adson's, Costoclavicular, Hyperabduction, Allen's and Roo's) more effective in diagnosing thoracic outlet syndrome?

AUTHOR

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CLINICAL SCENARIO

After eight months of physical therapy evaluations, doctors' visits and thousands of dollars spent on MRI's and x-rays I was diagnosed with Thoracic Outlet Syndrome (TOS) in the Fall of last year. I was lucky enough to have been able to receive a nerve conduction velocity free in class as part of my physical therapy curriculum. However, it was not until the shoulder unit of my musculoskeletal course that I learned about the tests available for Thoracic Outlet Syndrome. It was these tests that led my physician and I to narrow down TOS as the cause of my symptoms. With healthcare expenditure at an all-time high it is essential that we as health care providers try to reduce costs wherever possible without compromising patient care. For this reason, it is essential to determine whether or not it is worth thousands of dollars on expensive tests such as nerve conduction velocities to diagnose thoracic outlet syndrome, or if the relatively inexpensive special tests are as effective in diagnosing the condition.

SUMMARY OF SEARCH

There is limited evidence available on the topic of Thoracic Outlet Syndrome. Due to the overall lack of evidence of the topic, high quality studies related to this particular topic were scarce. Only 10 studies were identified as meeting both the inclusion and exclusion criteria of this appraisal. Majority of these studies were cohort studies or quasi-experimental designed studies making the overall quality of the evidence only fair. The initial inclusion and exclusion criteria were not sufficient in capturing the most relevant and useful studies and had to be extended to find the best results. Evidence demonstrates that the shoulder special tests have higher sensitivity and specificity when combined into a series of tests rather than individual tests. Nerve conduction velocity is not consistently used to diagnose TOS and helical CT provides the most detailed information on the location and cause of the compression; however, it is not a commonly utilized diagnostic measure. Additional information reveals that MRI also provides useful information in identifying areas of compression and fibrous bands in the region of the thoracic outlet. The key points for future research is the need for a larger body of research on the topic of thoracic outlet syndrome in general, in addition to larger more rigorous studies comparing the different diagnostic techniques.

CLINICAL BOTTOM LINE

Evidence suggests that there is still no "gold standard" in the diagnosis of Thoracic Outlet Syndrome. The shoulder special tests (Adson's, Hyperabduction, Costoclavicular, Allen's, Wright's and Roo's) are more effective in diagnosing thoracic outlet syndrome than nerve conduction velocity. The overall validity of these tests is improved when they are used as a series of tests in a pseudo-clinical prediction rule than when used individually. Nerve conduction velocity is primarily used to rule out other neurological conditions rather than diagnosing TOS. Physical therapists should feel comfortable in developing their own working diagnosis and treatment for Thoracic Outlet Syndrome based on the results of these tests. Referral for additional testing is only necessary when the results of these tests are inconclusive. Additional larger and more rigorous studies are needed to determine the true validity of these tests, as well as their effectiveness for the various types of Thoracic Outlet Syndrome.

This critically appraised topic has been individually prepared as part of a course requirement and has been peer-reviewed by one other independent course instructor

SEARCH STRATEGY

Terms used to guide the search strategy			
Patient/Client Group	**I**ntervention (or Assessment)	**C**omparison	**O**utcome(s)
Thoracic Outlet Syndrome (MeSH terms) Thoracic Spine Nerve Compression Syndrome (MeSH terms) Thoracic Outlet Neurologic Syndrome (MeSH terms)	Nerve conduction velocity NCV	Shoulder Special Tests Adson's Test Costoclavicular Test Hyperabduction Test Allen's Test Roo's Test	Diagnosis Thoracic Outlet Syndrome (MeSH terms) Nerve Compression Syndrome (MeSH terms) Thoracic Outlet Syndrome

Final search strategy:

Show your final search strategy from one of the databases you searched. In the table below, show how many results you got from your search from each database you searched.

PubMED (n=1910)

#1 MeSH Terms: nerve compression syndrome, thoracic outlet (n=1910)

#2 All Fields: Nerve conduction velocity (n=7782)

#3 All fields: Shoulder special test (n=178)

#4 All fields: Adson's Test (n=10)

#5 All Fields: Hyperabduction Test (n=14)

#6 #1 AND #2 AND #3 AND #4 AND #5 (n=0)

#7 #1 AND #2 (n=23)

#8 #1 AND #3 (n=1)

#9 #1 AND #4 (n=7)

#10 #1 AND #5 (n=6)

Databases and Sites Searched	**Number of results**	**Limits applied, revised number of results (if applicable)**
CINAHL	**10**	**Thoracic outlet syndrome AND Nerve Conduction Velocity**
PubMED	**23**	**MeSH terms (nerve compression syndrome, thoracic outlet) AND nerve conduction velocity.**
	1	**MeSH terms (nerve compression syndrome, thoracic outlet) AND shoulder special test**
	7	**MeSH terms (nerve compression syndrome, thoracic outlet) AND Adson's test**
	6	**MeSH terms (nerve compression syndrome, thoracic outlet) AND hyperabduction test**
The Cochrane Library	**17**	**MeSH terms (Thoracic Outlet Syndrome)**

INCLUSION and EXCLUSION CRITERIA

Inclusion Criteria
Systematic Reviews Randomized Control Trials Control Trials Cohort Studies Treatment protocol for Thoracic Outlet Syndrome Published up to September 2014 Published in English
Exclusion Criteria
Studied a population with Carpal Tunnel Syndrome, or other distal nerve compression syndrome Abstracts, letters to the editor and conference proceedings

RESULTS OF SEARCH

A total of 10 Relevant studies were located and categorised as shown in the following table (based on Levels of Evidence, Centre for Evidence Based Medicine, 2011) and Downs and Black quality assessment checklist.

Summary of articles retrieved that met inclusion and exclusion criteria

Author (Year)	Study quality score	Level of Evidence	Study design
Brismée J; Gilbert K; Isom K; Hall R; Leathers B; Sheppard N; Sawyer S; Sizer P (2004)	**16***	**2c**	**Outcomes research. Cohort Study.**
Demirbag D, Unlu E, Ozdemir F, et al. (2007)	**16***	**1b**	**Prospective, double-blind controlled study.**
Demondion X, Bacqueville E, Paul C, Duquesnoy B, Hachulla E, Cotten A. (2003)	**14***	**2b**	**Prospective study. Cohort study.**
Gillard J, Perez-Cousin M, Hachulla E, et al. (2001)	**19***	**2c**	**Prospective Study. Outcomes Research.**
Hanif S, Tassadaq N, Rathore MF, Rashid P, Ahmed N, Niazi F. (2007)	**12***	**4**	**Quasi-experimental prospective case series study.**
Lee AD, Agarwal S, Sadhu D. (2006)	**9***	**4**	**Retrospective study of 16 cases.**
Plewa MC, Delinger M (1998)	**16***	**2c**	**Cross sectional observational study.**
Povlsen B, Belzberg A, Hansson T, Dorsi M. (2010)	**AMSTAR (http://amstar.ca/Amstar_Checklist.php)** **9/11**	**1a**	**Systematic Review of randomized or quasi-randomized studies.**
Smith T, Trojaborg W. (1987)	**8***	**4**	**Case Series.**
Urschel H, J., Kourlis H, J. (2007)	**4***	**5**	**Discussion of the advancements in the treatment of TOS at Baylor University Medical Center over the past 50 years**

**All studies evaluated with the Downs and Black Quality Assessment Checklist excluded the power calculation question because this data was not available in any of the studies. This makes the total score of the test 26 rather than 30.*

BEST EVIDENCE

The following 3 studies were identified as the 'best' evidence and selected for critical appraisal. Reasons for selecting these studies were:

- **Demirbag D, Unlu E, Ozdemir F, et al. This article scored a 16 on the Downs and Black quality assessment tool, a tie with a few other studies. This study was selected over the other studies because of it was comparison between the use of MRI vs. Provocation Shoulder tests for thoracic outlet syndrome which was very similar to my clinical question and provided very useful**

information regarding the shoulder special tests.

- **Gillard J, Perez-Cousin M, Hachulla E, et al. This article was selected because not only was it the most relevant study to my clinical question but also it had the highest score on the Downs and Black Quality Assessment Scale of any study evaluated.**
- **Povlsen B, Belzberg A, Hansson T, Dorsi M. This study was the only systematic review I was able to find on the topic of thoracic outlet syndrome. Although only one study met the inclusion criteria to be reviewed in this review. The review itself was very high quality. The information presented in this review will provide useful information regarding thoracic outlet syndrome.**

SUMMARY OF BEST EVIDENCE

(1) Description and appraisal of Diagnosing Thoracic Outlet Syndrome: contribution of provocative tests, ultrasonography, electrophysiology, and helical computed tomography in 48 patients by (Gillard J, Perez-Cousin M, Hachulla E, et al., 2001)

Aim/Objective of the Study/Systematic Review:
The aim of this study is to determine the clinical and diagnostic usefulness of shoulder provocation tests, ultrasound, nerve conduction velocity and helical computed tomography in diagnosing thoracic outlet syndrome.
Study Design [e.g., systematic review, cohort, randomised controlled trial, qualitative study, grounded theory. Includes information about study characteristics such as blinding and allocation concealment. When were outcomes measured, if relevant] Note: For systematic review, use headings 'search strategy', 'selection criteria', 'methods' etc. For qualitative studies, identify data collection/analyses methods.
This study was a prospective cohort study focused on conducting outcomes research. There was no blinding of participants. Allocation and concealment are not applicable to this study.
Setting [e.g., locations such as hospital, community; rural; metropolitan; country]
Hospital. Lille Teaching Hospital. Lille, France
Participants [N, diagnosis, eligibility criteria, how recruited, type of sample (e.g., purposive, random), key demographics such as mean age, gender, duration of illness/disease, and if groups in an RCT were comparable at baseline on key demographic variables; number of dropouts if relevant, number available for follow-up] Note: This is not a list of the inclusion and exclusion criteria. This is a description of the actual sample that participated in the study. You can find this descriptive information in the text and tables in the article.
Forty-eight adult patients were selected for participation in this study. Patients included in the study presented within a 2 year period to either the department of rheumatology, internal medicine or rehabilitation of Lille teaching hospital with symptoms consistent with thoracic outlet syndrome. The authors outlined these symptoms as: fatigue in specific positions, paraesthesia, symptoms suggesting carpal tunnel syndrome, symptoms suggesting cervicobrachial neuralgia, permanent or intermittent edema, Raynaud's phenomenon, other distal trophic vascular disorders, and past or current history of upper limb venous thrombosis. Thirty-nine women and nine men made up the population. Of the 48 total patients studied 31 or 65% were diagnosed with thoracic outlet syndrome; of those 31, 26 were female with a mean age of 36 years (range 15-53), and 5 males with a mean age of 43 years (range 38-51). This left 17 participants who did not receive a final diagnosis of thoracic outlet syndrome; of these 17, 13 were females with a mean age of 42 years (range 29-61) and 4 were males with a mean age of 39 years (range 30-44).
Intervention Investigated [Provide details of methods, who provided treatment, when and where, how many hours of treatment provided]
(Two examiners, who were not identified, conducted a physical examination, and tests (listed below) before determining a final diagnosis for each of the patients. However, the purpose of the study was to determine the usefulness of the various tests. For this reason, the interventions are all listed and explained below)
Tests
1. Provocation Tests

a. Wright's test: arms start in neutral position and then abducted to 30 degrees, 60 degrees, 90 degrees and 180 degrees. Measurements are taken at the angle at which the patient's symptoms are reproduced and at which their pulse is abolished.
b. Hyperabduction test: the patient's arms are elevated and abducted with elbows bent and the patient is instructed to take a deep breath. Positive tests are measured either by the abolition of the pulse or symptom reproduction.
c. Roo's Test: In this test both arms are elevated, and abducted with the elbows bent. The patient is then instructed to open and close their hands for at least 3 minutes. A positive test is defined as a reproduction of the patient's symptoms.
d. Tinel's Test: This test is also known as Tinel's sign involves finger pressure and percussion in the infraclavicular and supraclavicular area. A positive sign is defined as a reproduction of the patient's symptoms.
e. Adson's Test: The patient's neck is fully extended and rotated toward the side that is being tested. The patient is instructed to take a deep breath. The test is considered positive if the patient's radial pulse is abolished or the position reproduces the patient's symptoms.

2. Ultrasonography- Examiners used B-mode ultrasonography and Doppler studies of all arteries and veins in subclavian region with a HDI 3000 APOGE 800+, with an 11-z MHz linear probe. The patency and structure of the subclavian blood vessels was taken with the patients sitting at rest and also while in the position for Adson's, Eden's and 90 degree Wright's test. Results were considered to be positive if they produced accelerated flow followed by turbulence and resulting in a signal stoppage. If signal was lost only in 180 degrees of Wright's test this was not considered significant. This intervention was performed with all 48 patients.
3. Electrophysiology- Electrophysiology studies were conducted on the motor component of the median and ulnar nerve with an F-wave analysis. Measurements were recorded of latency times, velocities, response amplitudes and ulnar nerve somatosensory evoked potentials. No additional information was given regarding who provided the intervention. 45 out of the 48 patients received this intervention.
4. Helical Computed Tomography (CT) Angiography- The examiners used a Somantum Plus 4A device for this intervention. The artery and/or veins were studied based on the individual's response to ultrasonography. The first patients (less than 10) underwent routine helical CT of the veins only. The examiners studied the veins in two positions: a neutral and dynamic position. The neutral position involved the patient lying supine with their arms by their side and their head in neutral, a pad between the scapulae and the patient taking a deep breath. The dynamic position was the same as the neutral position with the exception of the arms being abducted to 130-150 degrees in external rotation, with the elbow flexed, and with the head toward the side being examined. The images taken were from C7 to anterior extremity of the first rib. The pitch was set 1.0 or 1.5 and the collimation was 2 to 3 mm. An iodonized contrast agent (240 to 300 mg/ dLat a rate of 3 or 4 mL/s) was injected and multiplaner reformants were taken using 3D shaded surface displays, 3D volume rendering displays and 3D maximum intensity projection. A blood vessel lumen reduction of 50% or greater was considered to be clinically significant for this intervention. The exact location of the stenosis was determined via: distance between the first rib and the clavicle in neutral and dynamic test positions and structural changes in the scalene muscles and cervicothoracic junction. If changes were noted in the cervicothoracic junction a plain radiograph was also taken of the area. This intervention was performed in 47 out of the 48 participants.

Outcome Measures (Primary and Secondary)

[Give details of each measure, maximum possible score and range for each measure, administered by whom, where]

There were no outcome measures used in this study.

Main Findings

[Provide summary of mean scores/mean differences/treatment effect, 95% confidence intervals and p-values etc., where provided – if you need to calculate these data yourself, put calculations here and add interpretation later, under 'critical appraisal' on next page]

1. Provocation Tests
   a. Combined Sensitivity: Mean 72%
   b. Combined Specificity: Mean 53%
   c. Tinel's Test: 46% sensitivity, 56% specificity, positive predictive value (PPV) 63%, and negative predictive value (NPV) 39%
   d. Adson's Test: 79% sensitivity, 76% specificity, 85% PPV, 72% NPV
   e. Hyperabduction (Pulse Abolition): 52% sensitive, 90% specific, 92% PPV, 47% NPV
   f. Hyperabduction (Symptom Reproduction): 84% sensitive, 40% specific, 74% PPV, 55% NPV
   g. Wright's test (pulse abolition): 70% sensitivity, 53% specificity, 72% PPV, 50% NPV
   h. Wright's test (symptom reproduction): 90% sensitivity, 29% specificity, 69% PPV, 63% NPV
   i. Roo's Test: 84% sensitivity, 30% specificity, 68% PPV, 50% NPV
   j. Tinel's Test: 46% sensitivity 46% sensitivity, 56% specificity, 63% PPV, 39% NPV
   k. Only Adson's test and a pulse positive on the Hyperabduction test* were significantly correlated with the final diagnosis ($p < 0.05$). *the hyperabduction test was only performed on 31 patients.

l. When provocation tests were combined, combinations including Adson's test were significantly correlated with the final diagnosis ($p < 0.001$) and Wright's test combined with either Roo's or Hyperabduction (symptom reproduction) ($P< 0.05$). No significant changes were noted in any other pairs and the combinations improved the sensitivity and specificity than any test alone.
m. Adson's and Wrights (symptom): 79% sensitive, 76% specific
n. Adson's and Wright's (pulse): 54% sensitive, 94% specific
o. Adson's and Roo's: 72% sensitive, and 82% specific
p. Adson's and Hyperabduction (symptoms): 72% sensitive, 88% specific
q. Wright's (symptom) and Roo's: 83% sensitive, 47% specific
r. Wright's (symptom) and Hyperabduction (symptom): 83% sensitive, 50% specific
s. Wright's (pulse) and Hyperabduction (symptom):63% sensitive and 69% specific

2. Doppler Ultrasonography
   a. In the 48 patients studied, 19 had normal results on Doppler ultrasonography, including four with false positives. Of those with abnormal responses, 4 were found in the neutral position and 29 in the dynamic position. Based on these results the sensitivity of Doppler ultrasonography is 87% with a specificity of 88%. However, a significant improvement in specificity was noted when ultrasonography was combined with two, three or four positive provocation tests.
3. Electrophysiology
   a. The somatosensory evoked potentials were consistently normal in the 45 patients who underwent electrophysiology evaluation. The EMG findings resulted in 35 people with normal EMG results, 9 people with disruptions consistent with carpel tunnel syndrome, including three people with thoracic outlet syndrome, and 1 person with an EMG disruption in the C8-D1 region.
4. Helical CT
   a. Helical CT results were available for 53 vessels because the artery and vein were studies in 6 of the 47 patients who underwent this investigation. 21 evaluations were positive, 17 arteries and 4 veins, in people who received a final diagnosis of thoracic outlet syndrome. 17 evaluations were negative, 10 arteries and 7 veins, in people who did not receive a diagnosis of thoracic outlet syndrome. A single arterial exam produced a false-positive result. 4 patients who received a final diagnosis of thoracic outlet syndrome had vascular stenosis of less than 50% which was not considered significant positive for the purpose of this study. Only arterial finding, not venous, were significantly correlated with a final diagnosis of thoracic outlet syndrome ($p< .001$). Arterial findings produced a sensitive of 68%, and specificity of 90%. Additionally, the helical CT revealed the interscalene channel as the most common site of stenosis.

Original Authors' Conclusions

[Paraphrase as required. If providing a direct quote, add page number]

The authors of this study concluded that all of the interventions utilized in this study provide some diagnostic information regarding the diagnosis of thoracic outlet syndrome. They concluded that while the sensitivity and specificity varied for the different provocation tests, Adson's test, Pulse Abolition on the Hyperabduction test and Pulse Abolition on the Wright's test were the most effective in diagnosing thoracic outlet syndrome. The use of Doppler ultrasound enhanced the effectiveness of the provocation tests in diagnosing thoracic outlet syndrome if the patient had between two and four positive provocation test results. Additionally, they found that electrophysiology was not particularly effective in diagnosing thoracic outlet syndrome but was better utilized in ruling out other neurologic conditions. Finally, the author's concluded that helical CT can provide the most detailed information to medical professionals in regards to the mechanism and site of compression. However, this procedure is not a current element in pre-diagnostic screening for thoracic outlet syndrome.

Critical Appraisal

Validity

[Methodology, rigour, selection, sources of bias, quality score on methodology quality rating scale (indicate the quality assessment tool used and the maximum possible score on that scale, e.g., 7/10 on PEDro scale), appropriateness of analytical approach (e.g., adjustments for confounding variables, management of missing data).]

Comment on missing information in original paper.

Although the study was extremely useful for my clinical questions it did not contain the highest level of validity due to flaws in the study design. There were quite a few elements that could have created bias within the study. First and foremost, as identified by the authors, the fact that the interventions that were being examined contributed to the final diagnosis. Basically, the individual tests contributed to the final diagnosis which is what was used to determine the effectiveness of the tests. The interaction between these two variables can cause confounding of the results and skew the sensitivity and specificity values. Additionally, the authors continued to refer to the tests being studied as "interventions" which can be confusing for the reader, as the term intervention suggests that these tests were actually a type of treatment. Another potential source of bias in this study is investigator bias. There was never any information provided regarding the identity of the two primary researchers for the study. However, the paper referred to "two of us" administering the tests, suggesting that the authors were also the two investigators administering the examinations. This overlap could

lead to potentially biased results and interpretations of results. Overall, the methodology was fairly well executed. The researchers clearly outlined how each intervention was administered so that they tests could be reproduced for future research. I utilized the Downs and Black Quality Rating Scale to determine the quality of this study. The maximum score available on this scale was a 30; however, as none of the studies I evaluated for this clinical question included a power analysis in their results I omitted the power analysis of this scale making the new maximum score 26. This study scored a 19/26. There were areas of weakness in most of the major sub-categories including reporting, internal validity- bias, and internal validity confounding. In regards to reporting, the study failed to provide estimates of the random variability for the main outcomes, report any potential adverse events or describe principle or potential confounders and their distribution within the group. The internal validity of the study was weak because there was no attempt to blind study participants and investigators from the results or the intervention. The lack of randomization and blinding challenged the interval validity in terms of both bias and confounding. Based on the data provided, the reader is left to assume that no participants dropped out of the study as data was collected from all 48 patients that were evaluated. However, it would be useful to know how many people the authors suspected of having thoracic outlet syndrome were asked to participate in the study and how many actually participated. Additionally, the paper is missing any information regarding random variability in the data including standard deviation, standard error, etc… Finally, the overall strength and validity of the study would have been improved if the authors utilized a control group of those who were not diagnosed with thoracic outlet syndrome and compared their test results to those who were diagnosed with TOS. The information in this study was extremely useful for my clinical question because it directly addressed both interventions I was exploring; however, there were significant flaws in the research design that need to be considered.

Interpretation of Results

[Favourable or unfavourable, specific outcomes of interest, size of treatment effect, statistical and clinical significance, minimal clinically important difference. You may calculate effect size or confidence intervals yourself from the data provided in the article.] Describe in your own words what the results mean.

As the purpose of the study was outcomes research and comparing and contrasting the accuracy of different evaluation techniques it is difficult to label results as favourable or unfavourable. All in all, I would say the research was favourable because 31 of the 48 patients suspected of thoracic outlet syndrome actually left the clinic with that diagnosis. Effect size is unable to be calculated because each test was only administered to each patient one time and is not applicable to cohort studies. The strongest data supported the use of helical CT to determine the cause and location of the compression; however, there was evidence that the provocation tests especially when combined into a pseudo-clinical predication rule and combined with Doppler ultrasound can actually be very effective in diagnosing thoracic outlet syndrome. The evidence did not support the use of electrophysiology for the diagnosis of thoracic outlet syndrome, but indicated it may still be useful for ruling out other conditions. The most relevant data for this clinical question are the outcomes of the provocation tests. The data illustrates that Adson's test in conjunction with other tests is very highly predictive in diagnosing thoracic outlet syndrome, with a very low chance that this association is due to error. Pulse abolition with Wright's test and Hyperabduction test in combination with other provocation tests also is significantly associated with a diagnosis of thoracic outlet syndrome; however, there is a higher chance that this correlation may be due to chance. Additionally, the sensitivity and specificity which determine the tests ability to rule in or rule out a condition are enhanced by the use of Doppler ultrasound in addition the two to four positive pain provocation tests. The data indicates that if a person presents with between two and four positive provocation tests and a Doppler ultrasound they can be 87% sure that you can rule out the condition if the ultrasound was negative and 88% sure they do have TOS if the ultrasound is positive. Finally, the results of the helical CT demonstrate that if the patient presents with narrowing or stenosis that is visible via helical CT you can be 90% sure that the patient has thoracic outlet syndrome. This is the most definitive value present in the data. Helical CT also provides more specific information than any other intervention including the location and mechanism of compression. However, this is an extremely expensive procedure and not a procedure that is typically used for the diagnosis of TOS. Statistically, the data suggests there is no need to pay thousands of dollars in special tests to diagnose thoracic outlet syndrome because the provocation tests are just as effective as any of the other measures, especially when combined together. However, clinical significance is more challenging to calculate as there is no "gold standard" for diagnosis of thoracic outlet syndrome; thereby, making it extremely challenging and beyond my knowledge to calculate the minimal clinical important difference.

(2) Description and appraisal of The Relationship Between Magnetic Resonance Imaging Findings and Postural Maneuver and Physical Examination Tests in Patients with Thoracic Outlet Syndrome: Results of a Double-Blind, Controlled Study by Demirbag D, Unlu E, Ozdemir F, et al., 2007.

Aim/Objective of the Study/Systematic Review:

To compare and contrast the differences in magnetic resonance imaging (MRI) in neutral versus provocative positions, and to compare these results to findings from physical examination tests in people with Thoracic

Outlet Syndrome.

Study Design

[e.g., systematic review, cohort, randomised controlled trial, qualitative study, grounded theory. Includes information about study characteristics such as blinding and allocation concealment. When were outcomes measured, if relevant]

Note: For systematic review, use headings 'search strategy', 'selection criteria', 'methods' etc. For qualitative studies, identify data collection/analyses methods.

Prospective double blind control study. The primary outcomes measures were: Adson's test, the Halsted maneuverer, and the hyperabduction test. Additionally, all patients underwent an MRI in a neutral position and a provocative position. The results were compared at the costoclavicular space, interscalene triangle, and at the retropectoralis minor space for both of these positions.

Setting

[e.g., locations such as hospital, community; rural; metropolitan; country]

University physical medicine and rehabilitation out-patient and radiology clinics. University of Trakya, Edirne, Turkey.

Participants

[N, diagnosis, eligibility criteria, how recruited, type of sample (e.g., purposive, random), key demographics such as mean age, gender, duration of illness/disease, and if groups in an RCT were comparable at baseline on key demographic variables; number of dropouts if relevant, number available for follow-up]

Note: This is not a list of the inclusion and exclusion criteria. This is a description of the actual sample that participated in the study. You can find this descriptive information in the text and tables in the article.

There were 41 total participants. 29 patients and 12 healthy controls. The patient group included 23 women and 6 men, while the control group was composed of 10 women and 2 men. The mean age for the patients was 41.34 plus or minus 8.27 years; the mean age of the control group was 46.16 years plus or minus 7.69 years. All of the patients have positive bilateral thoracic outlet syndrome stress tests, and all control group participants were symptom free and had negative thoracic outlet syndrome stress test results bilaterally. Additionally, none of the patients had previously undergone surgery of the upper thoracic region before the MRI study and all participants provided informed consent to participate in the study. Participant complaints included: waking up with numbness in both extremities, swollen and tense hands in the morning, pain and weakness in the upper extremities during overhead activities and shoulder and arm pain especially when tired or during stressful times. None of the participants had a prior history of radiculopathy, entrapment neuropathy, or any other neurologic disease. Subjects had no motor or sensory loss with their deep tendon reflexes and there was no atrophy in any muscle group, cyanosis, objective edema or ischemia in the upper extremities. Only participants with bilateral positive findings on Roo's test and patients with symptoms in both arms were considered positive on the stress test and were included in the study. Healthy controls had no history of numbness in the upper extremities, neck or back areas and had negative results bilaterally on the stress test.

Intervention Investigated

[Provide details of methods, who provided treatment, when and where, how many hours of treatment provided]

Control

Not Applicable

Experimental

Not Applicable

Outcome Measures (Primary and Secondary)

[Give details of each measure, maximum possible score and range for each measure, administered by whom, where]

Adson's Test: The participant's arm that is being studied hangs down at their side and their head is turned toward the affected side. The patient is then instructed to breathe deeply while the tester monitors the radial pulse. The test is considered positive if the radial pulse stops or disappears. Conducted by a physical medicine and rehabilitation specialist who did not know which group they belonged to. The test findings were recorded as either positive or negative.

The Halsted Maneuver: Is conducted in an exaggerated military position where the participant assumes a military posture with the shoulders back and down to narrow the costoclavicular space. The tester monitors the

radial pulse and the test is scored a positive if the pulse disappears. Conducted by a physical medicine and rehabilitation specialist who did not know which group they belonged to. The test findings were recorded as either positive or negative.

Hyperabduction Test: Not described. Conducted by a physical medicine and rehabilitation specialist who did not know which group they belonged to. The test findings were recorded as either positive or negative.

Neutral Position MRI: MRI was performed using the 1-T system with 20mT/m maximum gradient strength. All examinations were performed with a standard body coil. After scout images were collected coronal and sagittal T1-weighted spin echo sequences with a repetition time of 510 and echo time of 14 were collected for both arms in an adducted or neutral position. For the sagittal images 16 contiguous slices for both sides were collected and the imaging time averaged to be approximately 20 minutes. Four radiologists who were blinded to the participant's physical examination findings evaluated the MRI scans both quantitatively and qualitatively. The quantitative analysis consisted of measurements of the interscalene triangle (the space between the anterior scalene muscle and the middle-posterior scalene muscle), maximum thickness of the anterior scalene muscle, minimal costoclavicular distance, maximum thickness of the subclavius muscle, and the retropectoralis minor space distance. The qualitative analysis involved an assessment of the interscalene triangle-prescalene space, costoclavicular space and retropectoralis minor space for side subclavian arteries, veins and brachial plexus compression. A reduction of more than 30% for arteries and 50% for veins plus the disappearance of perineural fat for the neural structure were accepted as positive for compression.

Provocative Position MRI: MRI was performed using the 1-T system with 20mT/m maximum gradient strength. All examinations were performed with a standard body coil. After scout images were collected coronal and sagittal T1-weighted spin echo sequences with a repetition time of 510 and echo time of 14 were collected for both arms elevated above the patient's head in approximately 130 degrees of abduction and approximately 130 degrees of flexion at the elbows. For the sagittal images 16 contiguous slices for both sides were collected and the imaging time averaged to be approximately 20 minutes. Four radiologists who were blinded to the participant's physical examination findings evaluated the MRI scans both quantitatively and qualitatively. The quantitative analysis consisted of measurements of the interscalene triangle (the space between the anterior scalene muscle and the middle-posterior scalene muscle), maximum thickness of the anterior scalene muscle, minimal costoclavicular distance, maximum thickness of the subclavius muscle, and the retropectoralis minor space distance. The qualitative analysis involved an assessment of the interscalene triangle-prescalene space, costoclavicular space and retropectoralis minor space for side subclavian arteries, veins and brachial plexus compression. A reduction of more than 30% for arteries and 50% for veins plus the disappearance of perineural fat for the neural structure were accepted as positive for compression.

Main Findings

[Provide summary of mean scores/mean differences/treatment effect, 95% confidence intervals and p-values etc., where provided – if you need to calculate these data yourself, put calculations here and add interpretation later, under 'critical appraisal' on next page]

There was no significant sex distribution between the two groups and no significant age differences between the two groups. In the participant group there was a significant difference between the neutral position values and the provocative position values, except in the retropectoralis minor distance. The control group had no significant difference ($p<.05$) between the two groups, except for the left anterior scalene muscle thickness and thickness of the right subclavius muscle ($p<.05$). The results showed a significant difference ($p<.05$) in the provocation positions between the two groups. Additionally, the researchers compared provocation change values between the participants and the controls and found no significant differences in the anterior scalene muscle thickness and retropectoral distance between the two groups ($p>.05$); however, there were statistical differences ($p<.05$) for the other measures. Revealing that participants had a more significant change in the provocative position than the controls. Next, the physical examination findings were compared to the positional change values detected on MRI. The results were as follows:

- Patients with a positive right arm Halsted maneuverer, an average minimum costoclavicular distance change of 19.33 mm. was recorded. Compared to a negative Halsted maneuverer and an average change of 9.57 mm. Resulting in a significant difference between the two groups ($P=.000$)
- Patients with a positive left arm Halsted maneuverer, an average minimum costoclavicular distance change of 16.3 mm. was recorded. Compared to a negative Halsted maneuverer and an average change of 10.25 mm. Resulting in a significant difference between the two groups ($P=.001$)
- There was no significant difference between for provocative change values for patients with positive Adson's test and hyperabduction tests and native Adson's and Hyperabduction tests ($P>.05$).
- There was no significant difference found for the ratio of positive findings of Adson's test between the participants and control s ($p>.05$)
- There was a significant difference in the positive ratio for the hyperabduction test and Halsted maneuverer between the two groups ($p<.05$)

The qualitative analysis of the participants versus healthy control revealed the following results.

- No compression findings in the upper extremities in the vascular or neural structures in the neutral position.
- In the provocative position, the symptomatic group had 8 arterial, 21 venous, and 3 neural compressions in the interscalene triangle-prescalene area on the right side. The left side yielded 2

arterial and 17 venous compressions.
- In the provocative position, the control group had 6 venous compressions in the interscalene triangle-prescalene area on the right side. The left side yielded 7 venous compressions.
- In the provocative position, the symptomatic group had 15 arterial, 19 venous, and 8 neural compressions in costoclavicular space on the right side. The left side yielded 14 arterial, 17 venous and 10 neural compressions.
- In the provocative position, the control group had 6 venous compressions in costoclavicular space on the right side. The left side yielded 1 arterial and 4 venous compressions.
- In the provocative position, the symptomatic group had 1 arterial, 9 venous, compressions in retropectoralis minor space on the right side. The left side yielded 8 venous compressions.
- In the provocative position, the control group had 4 venous compressions in retropectoralis minor space on the right side. The left side yielded 3 venous compressions.
- When the results were combined bilaterally for the participant group there was arterial compression in 40 segments (22.99%), venous compression in 91 segments (52.29%), and nerve compression in 21 segments (12.06%) out of a total of 174 segments.
- When the results were combined bilaterally for the control group there was arterial compression in 1 segments (1.39%), venous compression in 30 segments (41.7%), and nerve compression in 0 segments (0%) out of a total of 174 segments.

Finally, a unilateral fibrous band was found in the qualitative evaluation of 10 (34.48%) of the 29 participants. None were found in the control group.

Original Authors' Conclusions

[Paraphrase as required. If providing a direct quote, add page number]

Overall the author's concluded that MRI is a useful diagnostic tool for diagnosing Thoracic Outlet Syndrome as it can provide information on vascular and neural compression while also detecting fibrous band like structures that can be causing pressure. They identified a need for a larger study, which includes criteria such as body mass index to develop a standard for diagnosis. However, based on the results on this study they concluded that neutral and provocation position MRI can be beneficial for the diagnosis of TOS. Additionally, positional change values between the participant and control groups supported the results of both the qualitative analysis and clinical examination tests; however, when a qualitative analysis is being conducted provocation position imaging is sufficient without including the neutral position as no compressions were found in the neutral position. Finally, the author's concluded that they believe modified versions of this test can be used clinically to get more objective information in regards to the diagnosis of TOS.

Critical Appraisal

Validity

[Methodology, rigour, selection, sources of bias, quality score on methodology quality rating scale (indicate the quality assessment tool used and the maximum possible score on that scale, e.g., 7/10 on PEDro scale), appropriateness of analytical approach (e.g., adjustments for confounding variables, management of missing data).]

Comment on missing information in original paper.

The most glaring omission of this paper is the lack of description of methods for conduction Adson's test, hyperabduction test or the Halsted maneuverer. Although Adson's test and the Halsted maneuverer were initially introduced in the beginning of the paper, the exact protocol used was never detailed in the methods section of the paper. Additionally, the hyperabduction test was never described anywhere in the paper. These tests were listed as the main outcome measures of the paper but there was no description of how they were conducted for the purpose of this study. Without this information there is no way to ensure inter-tester reliability and no way to reproduce the test results because there is no way to determine if they tests were conducted the same way. Another flaw in the design of the study is the lack of description of how participants were identified, recruited, and if any subjects dropped out of the study. This information is critical in developing the internal validity of the study and ensuring that the study population is in fact a representative sample of the general population. Additionally, the study did not note any confounding variables that they needed to adjust for or if they were able to conduct all of the studies on all listed participants so there was no missing data. This study was evaluated with the Downs and Black quality assessment tool; however, the power analysis question of this assessment was omitted due to the fact that this study nor any of the other studies evaluated for this appraisal contained power calculations. By omitting this question this test had a maximum score of 26 and this test scored 16 out of 26. This paper lost quality assessment points not providing estimates of the random variability in the data, not describing any potential adverse events, not describing characteristics of patients that may have been lost to follow up, and not providing a description of the population from which subjects were recruited. One item that improved the overall validity and rigor of the study is that the radiologists reading the images as well as the physical medicine and rehabilitation specialists conducting the physical examination were blinded the study participant's group assignment, removing the chance for bias. Overall, the study had a very small study population but was well-designed and had generally good validity. The primary improvements needed are in reporting and simply providing the reader with basic information regarding the

study and not leaving this information to be implied. I agree with the author's that a larger more standardized version of this study would be beneficial to bolster and validate the results of this study.

Interpretation of Results

[Favourable or unfavourable, specific outcomes of interest, size of treatment effect, statistical and clinical significance, minimal clinically important difference. You may calculate effect size or confidence intervals yourself from the data provided in the article.] Describe in your own words what the results mean.

As the purpose of this study was to compare and contrast outcomes it is not applicable to judge the results as favourable or unfavourable as they did not influence the patient's outcome. However, the results do heavily favour the use of MRI imaging for the diagnosing thoracic outlet syndrome, with relatively little evidence to support the use of clinical examinations. I am unable to calculate effect size, as the outcomes were only administered at one point in time and effect size is not an applicable measure for cohort studies. Similarity, as this study is not tracking progress over time there is no minimal clinically important difference available for the clinical examination tests or the MRI results. The data shows the strongest correlation existing between a positive and negative score on the Halsted maneuverer and change in the costoclavicular distance with the provocation position in the right arm. This suggests that the Halsted maneuverer is the best test for assessing compressions in the costoclavicular region. This information would be useful for patients that are suspected to have compression coming from the costoclavicular region. However, the results were not quite as highly correlated in the left arm suggesting the hand dominance and arm use may influence the results of this test. Additionally, the results indicated no significant difference in the spacial changes in the costoclavicular region with the Adson's test or hyperabduction test. However, these tests may be better designed to assess compression in other areas that were not described. The results also revealed venous compression in both the participant and control group in the interscalene triangle, costoclavicular space, and retropectoralis minor space. These results indicate that venous compression may be a normal occurrence in the provocation positions and that this result should not be used as a stand-alone element in the diagnosing thoracic outlet syndrome. Finally, the results showed that the angle between the first rib and the horizontal on both the right and left side, the minimum costoclavicular distance on the right and left, the thickness of the right subclavius muscle and the right interscalene angle were all significantly different between the participants and the control group. This information suggests that these sites may be the best sites for conducting further assessments to develop normative data to use in the diagnosis of thoracic outlet syndrome. All in all the results indicate the MRI can be a useful tool in the diagnosis of thoracic outlet syndrome; however, there are numerous locations that compression can occur and additional research needs to be conducted to narrow down which tests are the most effective for diagnosing which location of compression.

(3) Description and appraisal of Treatment of Thoracic Outlet Syndrome (review) by Povlsen B, Belzberg A, Hansson T, Dorsi M, 2010.

Aim/Objective of the Study/Systematic Review:

The purpose of the study was to evaluate the potential benefits and adverse effects of the current treatments available for thoracic outlet syndrome.

Study Design

[e.g., systematic review, cohort, randomised controlled trial, qualitative study, grounded theory. Includes information about study characteristics such as blinding and allocation concealment. When were outcomes measured, if relevant]

Note: For systematic review, use headings 'search strategy', 'selection criteria', 'methods' etc. For qualitative studies, identify data collection/analyses methods.

Systematic Review.

Search Strategy: The authors searched The Cochrane Neuromuscular Disease Group Trials special register, the Cochrane Central Register of Controlled Trials, MEDLINE, EMBASE, CINAHL, AMED and the reference lists of selected articles to locate appropriate articles for this review.

Selection Criteria: The authors only selected randomized or quasi-randomized studies in any language of participants with the diagnosis of any type of thoracic outlet syndrome (neurogenic, vascular and disputed).

Methods: Four authors independently selected the trials to be included and extracted data. The included studies were rated for risk of bias according to the Cochrane Handbook for Systematic Reviews of Interventions.

Setting

[e.g., locations such as hospital, community; rural; metropolitan; country]

The study included in the systematic review was conducted in the Department of Neurosurgery at The John's Hopkins University in Baltimore, Maryland.

Participants

[N, diagnosis, eligibility criteria, how recruited, type of sample (e.g., purposive, random), key demographics such as mean age, gender, duration of illness/disease, and if groups in an RCT were comparable at baseline on key demographic variables; number of dropouts if relevant, number available for follow-up]

Note: This is not a list of the inclusion and exclusion criteria. This is a description of the actual sample that participated in the study. You can find this descriptive information in the text and tables in the article.

Participants receiving any operative or non-operative intervention for thoracic outlet syndrome of any aetiology or type. No restrictions were placed on the age, race, socioeconomic status, method of diagnosis or duration of symptoms.

Only 1 study was included in this review:

Sheth 2005 ***{published data only}***
Sheth RN, Campbell JN. Surgical treatment of thoracic outlet syndrome: a randomized trial comparing two operations. *Journal of Neurosurgery. Spine* 2005;**3**(5): 355–63.

32 additional studies were reviewed and excluded from this review.

The Sheth study had 55 participants with pain as their predominant symptom and who had been diagnosed with thoracic outlet syndrome by the senior author of the paper. Eight patients were lost to follow up, 4 from each intervention group. Of the final 47 patients who completed the follow up questionnaire 40 were women, with a mean age of 37 years old.

Intervention Investigated

[Provide details of methods, who provided treatment, when and where, how many hours of treatment provided]

Transaxillary First Rib Ressection: this is a surgical treatment procedure for thoracic outlet syndrome. Surgery is performed after the induction of general endotracheal anaesthesia in the supine position. A 6 to 7 mm curvilinear incision is made at the anterior part of the axilla, at the point just inferior to where the skin breaks away from the chest wall. The incision is designed to prevent any trauma for occurring at the long thoracic nerve. The dissection proceeds up the chest wall to the region of the first rib. The lower end of the first rib is then cleared of muscle and the pleura is mobilized away from the rib, the anterior scalene muscle is cut at the insertion site between the subclavian vein and artery, then the middle scalene is removed from the rib posteriorly. Finally the rib is removed in pieces, being careful not to create any traction injury to the brachial plexus.

Supraclavicular Neuroplasty of the Brachial Plexus: this is a surgical treatment procedure for thoracic outlet syndrome. Again, surgery is performed under general endotracheal anaesthesia in the supine position. A 7 cm. transverse incision is made one finger's width above the clavicle starting medially at the middle of the sternocladomastoid; the surgeon has to be sure to preserve the supraclavicular cutaneous nerve. The anterior scalene muscle is then divided completely and then the upper, middle and lower trunks of the plexus are freed circumferentially. This process is known as a complete neuroplasty. This procedure is then advanced to the C8-T1 nerve roots. Connective tissue arising in the apex of the pleura is removed from the area around the lower plexus. A small drain is placed in the wound at the end of the procedure.

Outcome Measures (Primary and Secondary)

[Give details of each measure, maximum possible score and range for each measure, administered by whom, where]

The primary outcome measure was change in pain rating on a validated visual analogue or similar scale at least 6 months after the intervention.

The secondary outcomes were change in muscle strength and adverse effects of the intervention.

Main Findings

[Provide summary of mean scores/mean differences/treatment effect, 95% confidence intervals and p-values etc., where provided – if you need to calculate these data yourself, put calculations here and add interpretation later, under 'critical appraisal' on next page]

The review was complicated by a lack of generally accepted criteria for diagnosing thoracic outlet syndrome, forcing the researchers to focus all of their attention to patients who already had the diagnosis of thoracic outlet syndrome. Additionally, none of the studies tracked patients' progress over time as an intervention was being

administered. Only one study, which the authors identified as having a high risk for bias, found that a transaxillary first rib resection was more effective in reducing pain than a supraclavicular neuroplasty for the brachial plexus, and neither group had any adverse effects.

Original Authors' Conclusions

[Paraphrase as required. If providing a direct quote, add page number]

The authors concluded that there is a severe lack of information regarding thoracic outlet syndrome. They concluded that the study was complicated not only by a lack of consistent criteria for diagnosing thoracic outlet syndrome but also the lack of high quality evidence available on this topic. The authors were unable to find any randomized trials to support the use of any of the treatments currently used today. The authors were able to locate one study with evidence suggesting that a transaxillary first rib resection may be more effective in reducing pain than a supraclavicular neuroplasty, but no evidence to support that either of these treatments would be better than no treatment at all. Finally, the authors concluded that there is a need for additional high quality studies that not only compare interventions but also compare no treatment to the interventions, universal outcome measures, and consistent diagnostic criteria on this topic.

Critical Appraisal

Validity

[Methodology, rigour, selection, sources of bias, quality score on methodology quality rating scale (indicate the quality assessment tool used and the maximum possible score on that scale, e.g., 7/10 on PEDro scale), appropriateness of analytical approach (e.g., adjustments for confounding variables, management of missing data).]

Comment on missing information in original paper.

A systematic review of only randomized control trials represents the highest level of evidence. Unfortunately, due to limited availability of high quality studies there was only one study of sufficient rigor to include in this review. By limiting the review to only one study the potential for bias increases as there is nothing to compare the results against. Additionally, this biases the results of the review as it does not provide a comprehensive list of all of the treatments available for thoracic outlet syndrome. This review scored a 9/11 on the AMSTAR quality rating scale, demonstrating the high methodological rigor of the systematic review. The fact that this study limited results to randomized or quasi-randomized studies eliminates potential sources of bias that are accompany some of the lower levels of evidence such as nonexperimental and quasiexperimental designs. Additionally, the authors explicitly described their selection criteria as well as their inclusion and exclusion criteria for selecting studies. It was not clarified until the reference section whether the studies included contained published or unpublished materials. The author's also pointed out that they did review the one study included according to the Cochrane Handbook for Systematic Reviews of Intervention. Unfortunately, the one study that was included was considered to be high risk for potential bias. The only flaw in the validity of this study is the fact that the authors failed to discuss the potential for publication bias of the study.

Interpretation of Results

[Favourable or unfavourable, specific outcomes of interest, size of treatment effect, statistical and clinical significance, minimal clinically important difference. You may calculate effect size or confidence intervals yourself from the data provided in the article.] Describe in your own words what the results mean.

The results of this review revealed an overwhelming gap in evidence related to thoracic outlet syndrome. The fact that there was only one randomized study that met the inclusion and exclusion criteria of the authors limits the generalizability of the results to the general TOS population. Based on the study that was included in the review, there is sufficient evidence to suggest that in terms of reducing symptom management a transaxillary first rib resection is significantly more effective in symptom management than a neuroplasty of the brachial plexus. However, both of these interventions are invasive surgical procedures. This reveals that there is no available high level research regarding more conservative methods of treatment. This skews the results, suggesting that surgical intervention is the best solution for pain resulting from thoracic outlet syndrome. In conclusion, there is significant evidence to support the use of a transaxillary first rib resection for the management of thoracic outlet syndrome; however, an overarching lack of evidence in the treatment of thoracic outlet syndrome makes these results less applicable to clinical practice. Additionally, the lack of quality studies available on the topic reduces this study's applicability to this clinical question.

IMPLICATIONS FOR PRACTICE and FUTURE RESEARCH

The evidence reviewed in this appraisal indicates that there is still no "gold standard" for the diagnosis of Thoracic Outlet Syndrome (TOS). Due in most part to its much debated history there is very little evidence on the topic of Thoracic Outlet Syndrome in general. This combination makes diagnostic evidence on this topic

even more scarce. The lack of a uniform definition of Thoracic Outlet Syndrome has led to a lot of diagnostic uncertainty for the condition. For this reason, Thoracic Outlet Syndrome has become a diagnosis of exclusion, where everything else must be ruled out before Thoracic Outlet Syndrome is ruled in, costing the patient and provider thousands of dollars and countless hours examination. However, the studies appraised in this review indicate that there is a clinical difference in the different diagnostic measures available for TOS. The shoulder special tests for thoracic outlet syndrome are a basic component of a physical therapist's training and are expected to be a skill that all licensed therapists are capable of performing. These tests which include Adson's test, Hyperabduction test, Roo's test, Allen's test, Wright's test, and the Costoclavicular test can be performed in any clinic environment and require no additional tools for administration. Evidence reveals that the psychometric properties of these tests are only fair for each test individually. The most psychometrically valid tests individually include Adson's test, Hyperabduction test with pulse abolition and Wright's test with pulse abolition. However, when these tests are combined into a series of tests in a clinical prediction rule type structure the psychometric properties become very good. Clinically, this means that physical therapists can effectively diagnose thoracic outlet syndrome without referring out for expensive special tests. Additionally, with the more positive test results produced via the provocation tests the therapist can become increasingly confident in their diagnosis of TOS.

The evidence also examined other evaluation methods including: Doppler ultrasonography, nerve conduction velocity, helical computed tomography and magnetic resonance imaging. Doppler ultrasonography has good psychometric properties in diagnosing TOS when used in both static and dynamic positioning; however, the sensitivity of this measure is significantly improved when combined with positive results on 2,3, or 4 positive test results on the shoulder special tests. Additionally, research indicates that nerve conduction velocity is not used to diagnose TOS but rather to rule out the presence of other peripheral nerve pathologies such as carpal tunnel syndrome, or cubital tunnel syndrome. Research regarding helical CT found that this test actually has the best psychometric properties of any of the evaluation methods, including the shoulder special tests, but is not commonly used in the diagnosis of thoracic outlet syndrome. Additionally, helical CT can provide the healthcare provider with the most information regarding the exact location and mechanism of the compression. Finally, evidence supports that magnetic resonance imaging (MRI) performed in a neutral and provocative position can be helpful in diagnosing TOS, as it can provide information regarding vascular or neurologic pressures within the compartment, as well as depict any scarring or fibrous bands that may be present in the region.

The evidence suggests that all of these measures can provide some useful information regarding the diagnosis of Thoracic Outlet Syndrome, where they differ is the cost and specialization required to administer them. The shoulder special tests, as previously mentioned, are tests taught in basic physical therapy curriculum and can be easily administered within an initial physical therapy evaluation at no additional cost. Physical therapists can perform nerve conduction velocities; however, specialized training is required to administer this test and it comes at an additional cost to the patient or their insurance. MRI's and Doppler ultrasonography must be administered by a radiologist or radiology tech and be "read" or interpreted by a radiologist[1]. The cost on average for an MRI is $2, 611 according to an article published by Time magazine, and the cost on average for a Doppler ultrasound is anywhere from $100-1,000[1,2]. Finally, helical CT must be performed by a specialized CT technician and overseen by a radiologist. On average a helical CT costs anywhere from $300-1,000[3].

The clinical bottom line is that a physical therapist is capable of diagnosing and conservatively treating thoracic outlet syndrome without referring out for expensive diagnostic testing. However, some of the alternative diagnostic measures including Doppler ultrasonography, MRI, and helical CT may be useful in diagnosing more unclear or difficult cases. Additionally, the information provided via these alternative methods may be more useful for physicians if conservative treatment for TOS fails and surgical intervention is required as they can provide more detailed information regarding the exact location or cause of the compression.

There is a dire need for additional research on this topic. First and foremost, more evidence and research needs to be focused on the condition of Thoracic Outlet Syndrome as a whole. It will be nearly impossible to develop and produce more robust evidence in regards to the diagnosis and treatment of TOS until there is sufficient evidence available regarding the nature, cause and existence of the condition. After the body of evidence surrounding the condition of Thoracic Outlet Syndrome expands, there is need for many more large randomized control trials and systematic reviews related to the diagnosis of this condition. Currently, a majority of the research on this topic is based on cohort studies and quasi-experimental studies which provide useful information but need to be validated by larger more robust randomized blind controlled trials before becoming an accepted element of clinical practice.

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