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# Functionality and Quality of Life Analysis of Conservative Treatment in Neurogenic Thoracic Outlet Syndrome

# Análise da Funcionalidade e Qualidade de Vida no Tratamento Conservador da Síndrome do Desfiladeiro Torácico Neurogênico

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**Abstract**

Neurogenic thoracic outlet syndrome is an entrapment neuropathy of the brachial plexus and its treatment is considered controversial. We aimed to assess the short-term outcomes of conservative treatment related to functionality and quality of life in patients with neurogenic thoracic outlet syndrome (NTOS) using a definitive diagnosis of the disease and validated assessment tools. This is a retrospective observational review of data from a prospectively maintained single center (community referral center) database of patients with NTOS and involved an analysis of patients who fulfilled the clinical diagnostic criteria of the Consortium for Outcomes Research and Education on Thoracic Outlet Syndrome (CORE-TOS) and completed the 12-Item Short Form Health Survey and Disabilities of the Arm, Shoulder, and Hand outcome measures questionnaires at the initial work-up and at 8 weeks after conservative physical therapy treatment. After 8 weeks, 32 (57.1%) of 56 patients showed clinically significant improvement in one or more of the analyzed questionnaire scores. The 12-Item Short Form Health Survey physical component scores and the Disabilities of the Arm, Shoulder, and Hand scores showed statistically significant improvements from baseline to follow-up (31.2 vs 33.4, $p = 0.004$; 68.1 vs 61.7, $p = 0.039$, respectively). The proportion of patients with a 12-Item Short Form Health Survey physical component score within the normal range was higher at the follow-up visit than at baseline (26.8% vs 10.7%, $p = 0.022$). We concluded that conservative treatment for NTOS had a short-term positive effect on quality of life and upper limb functionality.
**Keywords:** Physical Therapy Modalities. Brachial Plexus. Nerve Compression Syndromes.

**Resumo**

*A síndrome do desfiladeiro torácico neurogênica (SDTN) é neuropatia compressiva do plexo braquial e seu tratamento é controverso. Nós procuramos avaliar os resultados em curto prazo do tratamento conservador em pacientes com síndrome do desfiladeiro torácico neurogênico relacionados à funcionalidade e qualidade de vida utilizando critérios diagnósticos definitivos da doença e instrumentos de avaliação validados. Este é um estudo observacional retrospectivo de um banco de dados de um único centro (centro de referência comunitário) mantido prospectivamente de pacientes com SDTN. Foram incluídos para análise todos os pacientes que preenchiam os critérios de diagnóstico clínico do Consortium for Outcomes Research and Education on Thoracic Outlet Syndrome (CORE-TOS) e que completaram os questionários de medidas de resultados do 12-Item Short Form Health Survey (SF-12) e Disabilities of the Arm, Shoulder, and Hand (DASH) na avaliação inicial e 8 semanas após o tratamento conservador. Após 8 semanas, 32 (57,1%) dos 56 pacientes apresentaram melhora clinicamente significativa em uma ou mais pontuações dos questionários analisados. As pontuações dos componentes físicos do SF-12 e as pontuações de DASH mostraram melhorias estatisticamente significativas (31,2 vs 33,4, p = 0,004; 68,1 vs 61,7, p = 0,039, respectivamente). A proporção de pacientes com pontuação do componente físico do SF-12 dentro da faixa normal foi maior na consulta de acompanhamento do que no início do estudo (26,8% vs 10,7%, p = 0,022). Nós concluímos que o tratamento conservador da SDTN teve um efeito positivo em curto prazo na qualidade de vida e na funcionalidade dos membros superiores.*
**Palavras-chave:** *Modalidades de Fisioterapia. Plexo Braquial. Síndromes de Compressão Nervosa.*

## 1 Introduction

Neurogenic thoracic outlet syndrome (NTOS) is defined as an entrapment neuropathy of the brachial plexus. Compression of the plexus occurs in the scalene triangle (bordered by the anterior and middle scalene muscles and the first rib) and under the pectoralis minor tendon at the subcoracoid space. Tightening of the scalene and pectoralis minor muscles after acute trauma (e.g., whiplash injury) or chronic trauma (e.g., postural issues and repetitive motion of upper limbs) is responsible for the brachial plexus damage. Congenital malformations such as a cervical rib, elongated C7 transverse process, or cervical bands may contribute to the development of this disease. The main clinical features include cervicobrachial pain, and arm and hand paresthesia that are aggravated by overhead activities. NTOS is diagnosed when a compatible history and positive provocative maneuvers are present and a possible diagnosis of other conditions, such as carpal tunnel syndrome or cervical radiculopathy, is excluded. Objective findings such as intrinsic hand muscle atrophy and abnormal electrodiagnostic study occurs in only a few cases.[1]

While the etiology of NTOS is unclear, the disease does not seem to be a progressive neurological disease: only a minority of patients develop permanent nerve damage. NTOS is not typically observed in older adult patients, reflecting the possibility of spontaneous resolution in some patients. These observations suggest that a less aggressive approach to treating this complex disease is desirable. Conservative treatment for NTOS was first suggested by Peet[2] in 1956; since then, few studies regarding conservative treatment have been published, in contrast to a large number of surgical series. Despite the absence of evidence-based treatment recommendations and the predominance of surgical literature, the general consensus is that nonsurgical treatment should be applied in the initial management of NTOS.[3]

The literature addressing NTOS treatment usually addresses two main issues that make comparisons between studies challenging, namely, a lack of definitive clinical diagnostic criteria affecting patient selection and the utilization of non-validated tools to report outcome measures. An attempt to resolve the first issue was made by the Consortium for Outcomes Research and Education on Thoracic Outlet Syndrome (CORE-TOS) developing a consensus-based set of diagnostic criteria for NTOS[4]; however, this has not yet been widely utilized. Validated quality of life and upper limb functionality questionnaires such as the Disabilities of the Arm, Shoulder, and Hand (DASH)[5] outcome measure and the 12-Item Short Form Survey (SF-12)[6] questionnaires are increasingly used to report outcomes in the medical literature and have been used in a few surgical series concerning NTOS.[7-9]

This study aimed to assess short-term conservative treatment outcomes of NTOS related to functionality and quality of life and to evaluate the potential associations between clinical features at initial presentation and treatment outcomes. This novel strategy involving the use of validated patient-reported outcome measures, the SF-12 and DASH questionnaires, and the selection of patients with a definitive NTOS diagnosis based on the CORE-TOS clinical diagnosis criteria represents an important development in NTOS research.

## 2 Material and Methods

### 2.1 Study design

After obtaining approval from the Ethics Board of the Universidade Norte do Paraná under protocol number 3.201.778, a retrospective review of a prospectively maintained single center (community referral center) database was performed from January 2015 to December 2017. The need for written informed consent was waived by the ethics board due to the study's observational nature. Eligible patients comprised all those newly diagnosed with NTOS who had undergone conservative treatment after an initial evaluation. During the first visit, the SF-12 and DASH questionnaires were administered, and the patients were invited to begin a conservative treatment trial for 8 weeks. Subsequently, the patients were reevaluated using the SF-12 and DASH questionnaires, and adherence to the proposed treatment was noted. Patients were included in the analysis if they fulfilled the CORE-TOS clinical diagnostic criteria (Table 1) and had completed both questionnaires at the initial and follow-up visits.

**Table 1 -** CORE-TOS clinical diagnostic criteria

| |
|---|
| **Principal symptoms** |
| 1A: Pain in the neck, upper back, shoulder, arm and/or hand |
| 1B: Numbness, paresthesia and/or weakness in the arm, hand or digits |
| **Symptoms characteristics** |
| 2A: Pain/paresthesia/weakness exacerbated by elevated arm positions |
| 2B: Pain/paresthesia/weakness exacerbated by prolonged or repetitive arm/hand use, including prolonged work on a keyboard or other repetitive strain tasks |
| 2C: Pain/paresthesia radiate down the arm from the supraclavicular or infraclavicular spaces |
| **Clinical history** |
| 3A: Symptoms began after occupational, recreational or accidental injury of the head, neck or upper extremity including repetitive upper extremity strain or overuse |
| 3B: Previous ipsilateral clavicle or first rib fracture or known cervical rib |
| 3C: Previous cervical spine or ipsilateral peripheral nerve surgery without sustained improvement in symptoms |
| 3D: Previous conservative or surgical treatment for ipsilateral TOS |
| **Physical examination** |
| 4A: Local tenderness on palpation over the scalene tringle and/or subcoracoid space |
| 4B: Arm/hand/digit paresthesia on palpation over the scalene triangle and/or subcoracoid space |
| 4C: Objectively weak handgrip, intrinsic muscles or digit 5 or thenar/hypothenar atrophy |
| **Provocative maneuvers** |
| 5A: Positive upper limb tension test (ULTT) |
| 5B: Positive 3-minute elevated arm stress test (EAST) |

**Source**: adapted from Thompson[4].

To fulfill CORE-TOS clinical diagnostic criteria, patients must have had symptoms present for 12 weeks that were not satisfactorily explained by another condition and had to meet one criterion per category in four categories.

### 2.2 Diagnostic evaluation

Patients were diagnosed with NTOS after a detailed history and physical examination with provocative maneuvers; other diagnoses were excluded based on laboratory study findings. All patients underwent an upper limb electrodiagnostic study and cervical spine magnetic resonance imaging to rule out or identify other concomitant diagnoses, along with cervical spine and plain chest radiography to evaluate congenital malformations such as a cervical rib, C7 elongated transverse process, or a clavicle fracture. Most patients also underwent brachial plexus magnetic resonance imaging to evaluate whether rare diseases such as brachial plexus tumors were present and detect whether predisposing factors such as fibrous bands or signs of brachial plexus neuropathy were present. All other examinations were performed as required.

### 2.3 Conservative treatment protocol

All patients were oriented toward the upper limb positions and postures that might compromise the brachial plexus during daily activities and sleep. Home stretching and light aerobic exercises such as walking were also suggested. Recommended physiotherapy aimed to improve postural balance, pain control, and restore upper limb motion, and consisted of progressive stretching involving the upper trapezius, levator scapulae, and scalene muscles, and the sternocleidomastoid and pectoralis muscles, in addition to strengthening of the lower scapular stabilizers (i.e., the middle/lower trapezius and serratus anterior muscles). Physiotherapy was not supervised by the authors and was performed by different professionals. Medication for chronic pain was prescribed to all patients. Low dosage pregabalin 75 mg/day. or gabapentin 900 mg/day were the initial choices for medication. Nortriptiline 25 mg/day or duloxetine 30 mg/day were prescribed in cases of intolerance to pregabalin or gabapentin. All patients were also prescribed codein 30 mg plus paracetamol 500 mg for acute pain periods.

### 2.4 Outcomes measures

The DASH is a 30-item self-reported validated questionnaire designed to measure physical function and symptoms in patients with musculoskeletal and neurological disorders of the upper limb; it is commonly used in relevant orthopedic research.[5] The results of the questionnaire are reported on a 0 to 100-point scale, with lower scores indicating better functionality. The SF-12 questionnaire is a general health survey that uses 12 questions to assess function and well-being, and reports two separate measures (a physical and a mental component score [PCS and MCS, respectively]).[6] The PCS and the MCS were normalized to general population scores (mean score, 50 points; standard deviation, 10 points), with lower scores indicating a lower quality of life.

Clinically significant improvement was measured utilizing the minimal clinically important difference concept.[10] For the purpose of the present study, as a validated minimal clinically important difference for the SF-12 and DASH questionnaires in terms of NTOS was not available, an improvement in follow-up scores using half the standard deviation of the baseline scores was considered clinically significant, as suggested by Norman et al.[11] A clinically significant improvement in one or more questionnaire scores (PCS, MCS, and the DASH score) was considered a good outcome.

### 2.5 Data analysis

Statistical analyses were performed using SPSS Statistics for Windows v21 (IBM Corporation, Armonk, NY, USA) software. The Shapiro-Wilk test was used to check for normality. Demographic data were described as frequencies and percentages if categorical, or as means or medians if continuous. Questionnaire scores were reported as mean and standard deviation for the SF-12 and median and interquartile range for the DASH questionnaire. Paired Student's *t*- and Wilcoxon signed-rank tests were used to compare the baseline and follow-up questionnaire scores on the SF-12 and DASH questionnaires, respectively. Logistic regression with a Wald chi-square test was used to assess the influence of the selected variables on the outcomes. A McNemar test was used to compare the proportions within groups. Spearman's correlation test was used to determine the relationship between the SF-12 and DASH scores. Statistical significance was set at $p < 0.05$.

## 3 Results and Discussion

In total, 56 patients were evaluated, and their demographic data and clinical characteristics are shown in Table 2. During the observation period, 91% of the patients adhered to physiotherapy and had a mean of two sessions per week. Regular exercise was performed by 55% of the patients, while the home-based stretching/exercise program was adhered to by 89% of the patients.

**Table 2 -** Demographics and clinical characteristics (n = 56)

| | |
|---|---|
| **Age (years), mean (SD)** | 39.1 (8.7) |
| **Females, n (%)** | 51 (91.1) |
| **BMI, median (IQR)** | 24.7 (5.9) |
| **Symptoms duration (months), median (range)** | 36 (3-300) |
| **Laterality, n (%)** | |
| Right | 6 (10.7) |
| Left | 5 (8.9) |
| Bilateral | 45 (80.4) |
| **% Dominance** | |
| Right-handed | 98% |
| Left-handed | 2% |
| Symptomatic dominant hand* | 91.1% |
| Symptomatic non-dominant hand* | 89.3% |
| **Trauma history, n (%)** | |
| Chronic | 48 (85.7) |
| Acute | 8 (14.3) |
| **Type of work, n (%)** | |
| Sedentary | 30 (53.6) |
| Non-sedentary | 26 (46.4) |
| **Osseous factors, n (%)** | |
| Cervical ribs | 2 (3.6) |
| Elongated C7 transverse process | 3 (5.4) |
| **Painful conditions, n (%)** | |
| Shoulder issues | 18 (32.1) |
| Fibromyalgia | 9 (16.1) |
| Carpal Tunnel Syndrome | 7 (12.5) |
| Radiculopathy | 5 (8.9) |
| **CORE-TOS** | |
| Categories, median (range) | 5 (4-5) |
| Criteria, median (range) | 10 (7-12) |

CORE-TOS, Consortium for Research and Education on Thoracic Outlet Syndrome; IQR, interquartile range; NS, not significant; SD, standard deviation. *Non-significant difference between symptomatic dominant and symptomatic non-dominant hands (McNemar test, $p$ = NS)
**Source**: research data.

The baseline and follow-up questionnaire scores are presented in Table 3. After 8 weeks of conservative treatment,

the PCS and DASH scores showed statistically significant improvements, whereas the MCS scores did not change. In total, 32 (57.1%) patients had a clinically significant improvement in one or more scores (PCS, MCS, and DASH scores) and were considered to have a good outcome for further analysis. The proportion of patients with PCS scores within the normal range (ie, a PCS of >40) was higher at the follow-up visit than at the baseline visit (26.8% vs 10.7%, $p = 0.022$).

**Table 3 -** Questionnaire score results

| | Baseline* | Follow-up* | *p-v*alue** | MCID *** | MCID%**** |
|---|---|---|---|---|---|
| **PCS-12** | 31.9 (11.7) | 32.3 (12.4) | **0.007** | +3.73 | 44.6% |
| **MCS-12** | 43.0 (18.5) | 39.6 (18.6) | 0.101 | +5.90 | 21.4% |
| **DASH** | 68.1 (35.4) | 61.7 (33.1) | **0.039** | -11.25 | 17.9% |

DASH, Disabilities of the arm, shoulder, and hand outcome measure; PCS-12, physical component score of the Short Form 12 Health Survey; MCS-12, mental component score of the Short Form 12 Health survey;*Median (interquartile range);**Wilcoxon signed-ranks test;***MCID, minimal clinical important difference value (equals half of the standard deviation);****MCID%, percentage of patients achieving the MCID
**Source**: research data.

The effects of the selected variables on the outcomes are presented in Table 4. None of the analyzed variables had a significant effect on the outcome. The baseline and follow-up PCS and the DASH scores had a moderate to strong negative correlation (−0.60–−0.72, $p < 0.001$).

**Table 4 -** Univariate logistic regression analysis for good outcome

| Predictor | OR (95% CI) | *p*-value |
|---|---|---|
| Male | 0 | 0.999 |
| Age, <40 years | 0.87 (0.31-2.50) | 0.803 |
| Symptoms for <2 years | 0.99 (0.35-2.84) | 0.992 |
| Associated painful conditions* | 0.88 (0.31-2.54) | 0.817 |
| Chronic trauma | 1.67 (0.36-7.77) | 0.515 |
| Sedentary work | 1.17 (0.41-3.34) | 0.774 |
| Obesity (BMI >30 kg/m$^2$) | 2.68 (0.61-11.78) | 0.191 |

BMI, body mass index; CI, confidence interval; OR, odds ratio ; *Fibromyalgia, carpal tunnel syndrome, radiculopathy, shoulder issues
**Source**: research data.

The present study assessed the outcomes of short-term conservative treatment for patients with NTOS using well-defined diagnostic criteria and validated outcome tools. The results showed improvement in the quality of life and upper limb functionality in 57% of patients based on the minimal clinically important difference approach. Previous studies have reported the benefits of conservative treatment for NTOS.[12,13] Good outcome rates in both the short- and long-term after conservative treatment vary widely in the literature, but comparisons between studies are challenging owing to inconsistent clinical diagnostic criteria and a lack of validated evaluation tools.[14-17]

Short-term outcomes following conservative treatment have been reported. Novak et al.[14] evaluated 42 patients with NTOS and, after a mean of 3 months of treatment, 25 (59.5%) patients reported symptom improvement, whereas 17 (40.5%) patients reported no improvement or worsening of symptoms. In a prospective study of 50 patients with NTOS, Hanif et al[15] showed that after 6 months of treatment, 31 (62%) patients had full recovery or showed marked improvement, whereas 19 (38%) showed partial or no improvement. Pain was evaluated using a visual analog scale, which showed a statistically significant reduction in scores at the follow-up visit (5.8 vs 1.9, $p < 0.0001$).

The long-term outcomes of conservative treatment were reported by Landry et al[16] in 64 patients after a 4-year follow-up period. Twenty (31.2%) patients showed significant symptom improvement, whereas 44 (68.8%) showed poor outcomes. Opioids were used by 23% of patients, and only 14% were medication-free. Bosma et al.[17] also reported the long-term results of conservative treatment in 16 patients with NTOS who were followed up for a mean of 33 months. Twelve (75%) patients healed or improved, while four (25%) showed no change or worsening symptoms. A previous study[14] reported that patients who were overweight (a body mass index of >25 kg/m$^2$) and those with distal compressive neuropathies (carpal and cubital tunnel syndromes) were significantly less likely to report complete or almost complete pain relief ($p < 0.04$). No clinical factors evaluated in that study had an effect on the outcomes.

The strengths of the current study were the utilization of validated clinical diagnostic criteria and outcome evaluation tools; however, its limitations included a short follow-up period, no control group, and unsupervised physiotherapy.

## 4 Conclusion

Despite some limitations, the findings of the present study indicated that conservative treatment for NTOS had a short-term positive effect on quality of life and upper limb functionality. Future studies should focus on long-term follow-up of conservative treatment and on trials comparing surgical decompression with conservative treatment. The choice of appropriate treatment should be based on individual preferences until high-quality randomized trials on NTOS treatment are performed.

## Data Availability

The datasets generated and/or analyzed for this study are available from the corresponding author upon reasonable request.

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