Conservative Treatment of Thoracic Outlet Syndrome: A 2-Year Follow-Up

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ABSTRACT. Lindgren K-A. Conservative treatment of thoracic outlet syndrome: a 2-year follow-up. Arch Phys Med Rehabil 1997;78:373-8.

Objective: To evaluate a conservative therapy program that aims to restore normal function to the upper thoracic aperture in patients with thoracic outlet syndrome (TOS).

Design: A descriptive study of consecutive patients with a positive TOS index seen from 1988 to 1993. After therapy, the patients were followed for a mean period of 24.6 months.

Setting: Therapy was initiated primarily in an inpatient rehabilitation ward over an 11.4-day (range 4-24 days) stay.

Patients: One hundred nineteen patients (28 men and 91 women) with a positive TOS index participated. At admission, 50% of the patients were employed, 48% were on sick leave or retired, and 2% were unemployed.

Interventions: The patients received instructions on how to restore the normal function of their cervical spine and upper thoracic aperture by means of home exercises.

Main Outcome Measures: The efficacy of the treatment program was assessed by the frequency of return to work, normalization of the motion of the cervical spine and upper thoracic aperture, and subjective satisfaction with the outcome.

Results: At the follow-up examination, 88% of the patients were satisfied with the outcome of their treatment, and the ranges of motion of the cervical spine and upper thoracic aperture had normalized in 8 of 10 patients. Seventy-three percent of the patients returned to work after the therapy, either directly or after retraining, and 88% of the patients carried through the recommendations given at discharge during long-term follow-up. Normalized grip strength and Tinel's sign predicted patient satisfaction ($p < .001$) and return to work ($p < .001$). Return to work was more often successful if the work was sedentary rather than heavy ($p < .05$).

Conclusions: The treatment program provides relief to most patients with symptoms of TOS. If the symptoms are not relieved, the differential diagnosis should be reviewed. Conservative therapy with the aim of restoring the function of the upper thoracic aperture is to be recommended, and long-term follow-up is advisable.

BRACHIALGIA, WEAKNESS, pain, and discomfort in the upper limbs are common. Diagnosis is difficult because of the many pain-sensitive structures in the neck, the thoracic upper aperture, and the upper limbs. If other causes such as a herniated cervical disk, rotator cuff rupture, tumors, peripheral nerve entrapment, and other neurologic diseases have been excluded, and the symptoms can be provoked during examination, the case is often classed under thoracic outlet syndrome (TOS). The term "thoracic outlet syndrome" was coined by Peet et al in 1956[1] to describe several disorders attributed to mechanical compression of neural and/or vascular structures between the base of the neck and the axilla.

According to recent critical studies, good results after surgery for TOS are achieved in less than 40% of all cases.[2-4] Even the use of firm, stated operational criteria yields no more than 28% of symptom-free patients,[4] and the reported recurrence rate can be as high as 20%, with cases often ending in litigation.[5] The complications after surgery for TOS may be severe,[6] and conservatism in the treatment has been encouraged in recent years.[7-10] Despite recommendations of conservatism, there are few studies reporting conservative management of TOS.[8,11,12] This study evaluates long-term outcome after conservative management of patients with TOS, using a specific therapy program.

PATIENTS AND METHODS

During a 5-year period (1988-1993), 139 patients (33 men and 106 women) were admitted to a rehabilitation clinic with symptoms of arm pain and possible TOS. A TOS index was used to distinguish patients with probable TOS from those with more obscure arm pain. A total of 119 patients (28 men and 91 women) were found to have a positive TOS index,[13] ie, at least three of the following four criteria were met: a history of aggravation of symptoms with the arm in the elevated position; a history of paraesthesia in the segments C8-T1; tenderness over the brachial plexus supraclavicularly; and a positive "hands-up" test (Roos test = arms in the "stick-up" position [abduction-external rotation] and the fists repeatedly opened and closed for 3 minutes; if the patient's symptoms are thus provoked, the Roos test is considered to be positive). These patients were entered in the study.

For the 119 patients in the study, the women had a mean age of 42.4 years (range 19-58 years) and the men 39.4 years (range 26-63 years). All the patients had been referred to the clinic for evaluation of the option of surgical intervention because of failure in previous conservative treatment. Former conservative therapy had consisted mainly of passive therapy modalities such as massage and ultrasound. Shoulder girdle exercises had been recommended to some of the patients, but only a few received any home exercises.

Of the study patients, 62% had been referred to the clinic by a department of surgery (neurosurgery, orthopedics, or hand surgery) and 38% by a department of occupational medicine. The social status and other characteristics of the patients at admission are presented in table 1. All the patients had undergone at least the following examinations before admission: chest X-ray, cervical X-ray, electroneuromyography (ENMG) and somatosensory evoked potential (SEP) studies of the affected limb. Some of the patients had also been examined by cervical

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Submitted for publication April 29, 1996. Accepted in revised form September 30, 1996.

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0003-9993/97/7804-4002$3.00/0

Table 1: Social Status and Other Characteristics of Patients at Admission

	Women (N = 91)	Men (N = 28)
Mean age, yrs	42.4	39.4
Employed	48 (52.7%)	12 (42.9%)
On sick leave	32 (35.2%)	8 (28.6%)
Retired	9 (9.9%)	8 (28.6%)
Unemployed	2 (2.2%)	0
Mean duration of symptoms, mo	36.2	32.6
Mean duration of sick leave, mo	6.3	8.0
Previous operations on the same limb	16 (17.6%)	10 (35.7%)
Sedentary work	55 (60.4%)	9 (32.1%)
Heavy labor	35 (38.5%)	18 (64.3%)

myelography and/or magnetic resonance imaging (MRI) of the cervical spine.

The clinical examination at admission included a thorough assessment of the ranges of motion of the cervical spine, shoulder girdle, elbows, and wrists. Not all patients were examined by the same clinician at admission and at follow-up. The cervical movements examined were defined as follows: forward passive flexion (the examiner pressing the patient's chin to the patient's chest), extension (look at the ceiling), lateral flexion (ear to shoulder), and rotation to both sides of the neutrally positioned cervical spine. The cervical rotation lateral flexion (CRLF test) was also performed, a positive finding indicating a malfunction of the first rib.[14] In this test, the neutrally positioned cervical spine is first passively and maximally rotated away from the side to be examined. In this position, the cervical spine is gently flexed as far as possible, moving the ear towards the chest. The test is considered negative if the movement is possible up to 70°. The test is positive if this movement is impossible or the range of the movement is no more than half of that on the asymptomatic side. A neurological examination was done, and grip strength was measured. No TOS provocation test other than the Roos test, included in the TOS index, was administered because the other tests are considered unreliable,[8] and positive test findings are common in the normal population.[15,16] If palpation of the small pectoral muscle and the lateral epicondyles of the humerus revealed tenderness, this was recorded. Tenderness over the nerves when palpated from the axilla to the wrist was considered as a positive Tinel's sign, indicating possible compression of the nerve somewhere along its course. The clinical findings at admission are presented in table 2.

Therapeutic Model

The therapy was administered primarily in a rehabilitation ward, and only in a few cases on an outpatient basis. The patients received instruction on how to restore the normal function of the cervical spine and upper thoracic aperture by means of a few simple home exercises. The therapy was planned individually depending on the clinical findings. The mean inpatient period was 11.4 days (range 4-24 days).

Absence of symptoms is purely subjective, and psychosocial aspects and their influence on the symptoms should always be taken into account.[8] The staff in the ward consisted of registered nurses, licensed practical nurses, and physiotherapists. Consultation with a psychiatrist, a psychologist, or a social worker was arranged as required. An occupational therapist was also available.

Table 2: Clinical Findings in All Patients (N = 119) at Admission

Restricted movements of the cervical spine	19 (16.0%)
Positive CRLF test	96 (80.7%)
Tenderness over small pectoral muscle	47 (39.8%)
Tenderness over epicondyles	25 (21.0%)
Positive Tinel's sign	65 (54.6%)
Reduced grip strength	94 (79.0%)

Fig 1. Shoulder girdle exercises consisted of movements where the patient brought the shoulders backward and up (left), flexed the upper thoracic spine, brought the shoulders forward and down (middle), and then straightened the back and brought the shoulders backward (right). These exercises were repeated 5 to 10 times.

The therapy started with shoulder exercises, the purpose of which was to restore the movement of the whole shoulder girdle and provide more space for the neurovascular structures (fig 1). Guidance on how to restore and maintain the functions of the upper parts of the cervical spine (occipitoatloid motion) were administered after that (fig 2), because the movement of the upper cervical spine was found to be restricted in many cases.

Fig 2. The movement of the upper cervical spine can be effectively normalized by keeping the back and head firmly against a wall and then lowering the chin against the chest with the back of the head still touching the wall. The exercise can be made more effective by pressing the head down by hands. The exercise is repeated 5 to 10 times.

Fig 3. Normal function of the first ribs and the upper aperture can be achieved by activation of the scalene muscles by the patient. The patient first activates the anterior scalene muscles by pressing the forehead against the palm, with the cervical spine being all the time in a neutral position (left). The middle scalene muscles are activated by pressing sidewards against the palm (middle), and the posterior scalene muscles by pressing the back of the head against the palm (right). The exercises are done five or six times for a duration of 5 seconds each and with about 15 seconds between the exercises. The exercises are done to both sides. (Reprinted with permission.[46])

A restriction of this movement may be caused by tenseness of the middle scalene muscle, which is attached to the transverse processes of C1-C6.

The most important were exercises to activate the anterior, middle, and posterior scalene muscles (fig 3). These exercises have been shown to correct any malfunction of the first ribs, thus normalizing the function of the upper thoracic aperture[8,17] and enabling normal movement of the first ribs. Stretching of the muscles of the shoulder girdle involved the upper part of the trapezius muscles, the sternocleidomastoid muscles, the levator scapulae muscles, and the small pectoral muscle. Further stretching exercises were administered as needed, depending on the clinical findings in the individual case. The stretching exercises were administered according to the guidelines presented by Evjenth and Hamberg.[18] Two of the stretching exercises are shown in figure 4.

Muscle strengthening was administered according to the findings of the physical examination. We almost always included strengthening exercises for the anterior serratus muscle,

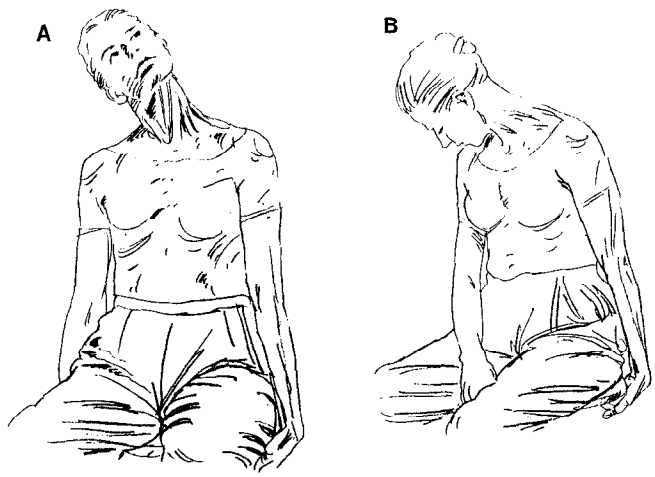

Fig 4. (A) The anterior muscles of the cervical spine can be effectively stretched by grabbing a chair with the left hand and then bending the upper part of the body to the right. The head is then turned towards the ceiling. This position should be held for 5 to 10 seconds. The patient then relaxes, and repeats the exercise five times. (B) An effective stretching exercise involving mainly the levator scapulae muscle.

Table 3: Patient Satisfaction and Clinical Findings After Treatment

Satisfied with outcome	88.1%
CRLF test negative and a normal range of cervical spine motion	81.5%
Grip strength normal if reduced at admission	64.9%
Tinel's sign normal if positive at admission	58.5%

thus enhancing the stability of the scapula. The patients were discharged from the ward after the functions of the cervical spine and upper thoracic aperture had normalized. At discharge, the same clinical examination was done as on admission, and the staff gave recommendations about the future to the patient. These alternative recommendations were: return to previous work, return to work through re-education, or retirement because of disabling symptoms. The patients were followed up at long term because relapses are common and there is no doubt that some individuals need to continue at least some level of exercising for a very long time.[19] The mean follow-up time was 24.6 months (range 0-60 months). The patients continued doing the exercises learned in the ward, and correct performance of the exercises was checked in conjunction with the follow-up examinations. The patients were encouraged to continue with the exercises even after the present study, in order to maintain normal function.

Statistical Analysis

The chi-square test or Fisher's exact test was used for statistical analysis as appropriate.

RESULTS

The radiographic and neurophysiological examinations before admission were done to exclude other causes for the symptoms. These examinations were normal in the patients entered into the study.

At discharge from hospital, 88.1% of the patients were satisfied with the outcome, ie, their symptoms had either disappeared or were much abated, or the real cause of the symptoms had been diagnosed. The clinical findings after treatment are presented in table 3. A negative Tinel's sign indicates that any irritation of the nerves along their course had diminished. Patient satisfaction and return to work if grip strength and Tinel's sign were normalized are shown in table 4. Return to work was more often successful ($p < .05$) if the work was sedentary rather than heavy (table 4).

Psychiatric or psychological consultation was needed by 6.9% of the patients and the services of an occupational therapist by 16.1%. The occupational therapist prescribed personal aids, such as cervical collars, arm splints, etc. Within the follow-up

Table 4: Effect of Clinical Findings (Grip Strength and Tinel's Sign) on Patient Satisfaction and Return to Work, and Return to Sedentary and Heavy Work

	No	Yes
Patient satisfaction/return to work		
Grip strength normalized	0/6	61/54
		$p < .001/p < .001$
Grip strength reduced	12/22	20/10
Tinel's sign negative	0/5	38/31
		$p < .001/p < .001$
Tinel's sign positive	11/19	15/7
Return to work*		
Sedentary work	11	51
		$p < .05$
Heavy work	19	33

* Five observations missing.

Table 5: Recommendations at Discharge

Return to former work	62.6% (72)*
Re-education	10.4% (12)*
Retirement	26.1% (30)*
Recommendations carried through during follow-up	87.9% (102)†
Retirement interrupted	40% (7)

* Five missing observations.
† Three missing observations.

period, 87.9% of the patients carried through the recommendations given at discharge (table 5). Eight patients required brief further guidance in the rehabilitation ward during the follow-up because of recurrence of symptoms. Seven of the previously retired 17 patients were able to interrupt their retirement and return to their pre-illness work. Two patients underwent surgery (first rib resection), one because of her own wish and the other because conservative treatment failed to normalize her restricted cervical motion. In the first case, the surgical procedure did not relieve the symptoms but the patient was able to return to work, and in the second case surgery succeeded in restoring normal movement and in removing the patient's symptoms.

Of the patients who were recommended retirement because of symptoms, the primary problem was found to be other than TOS. The final diagnoses of these patients are presented in table 6.

DISCUSSION

Cherington[20] stated in 1991, "It is important for surgeons and primary care physicians to be aware of the rising tide of scepticism surrounding the diagnosis and treatment of the thoracic outlet syndrome." This scepticism can be seen in recent reviews, especially those dealing with the management of TOS.[8,10] Scepticism is indeed justified for several reasons. The most often diagnosed and surgically treated form of TOS in the United States, disputed N-TOS, has no objective clinical, radiologic, or electrodiagnostic criteria. Serious complications such as causalgia, brachial plexus injury, and even death have been reported as a result of the surgical treatment of this syndrome that merely consists of symptoms without any objective signs.[6]

Some authors claim the results of surgical management to be good or excellent in more than 90% of patients. Different studies, however, are difficult to compare because of the various criteria used to assess the outcome. In addition, the numbers of patients have ranged from 26 to 1,336 and the follow-up time from 1 month to 15 years.[8] Some authors do not state the follow-up time at all or use vague terms such as "during the past 17 years."[8] There have only been a couple of studies in which the follow-up examination was done by independent examiners not involved in the surgical procedure or patient selection.[8] This seems to affect the results after surgery. The surgical literature appears to concentrate on the possibility of skeletal or soft tissue anomalies as the causes of the symptoms. According to Roos, such anomalies are always the reason behind symptoms of TOS.[21] However, only a few other surgeons have observed such anomalies.[22] This etiology seems obscure. Most TOS patients are young women doing sedentary work, and TOS symptoms are seldom seen in patients older than 50 years of age.

Table 6: Final Diagnoses of Patients Recommended Retirement Because of Sustained Symptoms (N = 30)

Psychiatric cause	6
Reflex sympathetic dystrophy	6
Unsuccessful resection of first rib	4
Polyneuropathy	2
Herniation of disc in the cervical spine and postoperative symptoms after discectomy	4
Multiple sclerosis	2
Cervical spondylosis	1
Hemiparesis	1
Whiplash	1
Unsuccessful scalenotomy	1
Complication after coronary bypass operation	1
Clavicular fracture	1

In a recent human cadaver study, only 10% had a bilaterally normal anatomy, and it is suggested that fibrous bands confer a predisposition to TOS symptoms after stress or injury.[23] Thus, these anomalies are frequent but they are almost impossible to detect preoperatively. Even if anomalies are seen on MRI,[24] it does not seem justified to correlate clinical symptoms with MRI abnormalities.[25] With these facts in mind, a well-planned conservative therapy model is needed, as are more studies evaluating the efficacy of different programs.

The outcome of conservative therapy varies among different studies. Sällström's program brought relief in 83% of patients with mild symptoms but in only 9% of those with severe symptoms.[26] According to the report of a program by Lederman, 65% benefited from conservative therapy.[27] Ingesson et al[28] reported that 50% responded primarily and 70% after a follow-up of 6 months. Even a success rate of 100% has been reported.[11] In the latter study a positive Adson's test was used as a criterion for TOS; today, however, a positive result in this test is considered to be a normal finding.[13] Exercise protocols reported in the literature include many maneuvers that may be poorly tolerated by patients with TOS.[29] In a study by Novak et al,[12] the patients investigated and treated even included those with concomitant distal nerve compression. Almost all authors have emphasized exercises to improve patients' posture,[1,30-32] as well as strengthening exercises of the shoulder girdle.[1,27,33-35]

Osteopathic manipulative treatments have been used to expand the thoracic outlet; mobilization of the first ribs is considered to be essential in the therapy.[36] Nevertheless, mobilization of the first ribs may also provoke symptoms,[28] and the benefit of deep massage "to mobilize the first rib" has been questioned.[29]

The conservative therapy model presented here takes into account the whole upper thoracic aperture and is based on functional findings in each patient. The program seeks to restore the function of the cervical spine and upper thoracic aperture before other therapeutic decisions are taken, thus differing from other therapy models. In this model, psychosocial factors, not presented in other studies, are also taken into account.

In the present study, more than 90% of the patients had a positive CRLF test indicating a malfunction of the first rib.[8,17] This test or other means of analyzing the function of the first ribs in TOS patients has not been presented previously in larger series of TOS patients. The movement of the cervical spine was also restricted in many of the present patients, a finding in many studies.[3,11,37] It has been hypothesized that a malfunction of the first rib (a positive CRLF test) may restrict the flexion of the cervical spine. This might be explained by restriction of the flexion of the upper part of the thoracic spine, resulting in total restriction of the flexion of the cervical spine.[8]

The present therapeutic approach proceeds logically from shoulder exercises to restoration of the mobility of the cervical spine. The following exercises, most importantly activation of the scalene muscles (fig 3),[8,17] are aimed at normalizing the movements of the first ribs. I have previously postulated that subluxation of the first rib at the costotransverse joint is associated with malfunction of the first rib.[8,17] As early as 1949, Shulman[38] showed that the first ribs bear the greatest stress at the costotransverse joint. Static work that stresses the upper extremities may further increase the existing stress, thereby affecting the function at this joint. The lack of a superior supporting ligament may also explain why the costotransverse joint of

the first rib is relatively weaker than those of the other ribs.[38] According to Machleder,[39] repetitive mechanical effort on the job will eventually expose the anatomic weakness. If the movement of the first rib is disturbed by subluxation at the costotransverse joint, the kinesiology of the upper aperture may be affected and the scalene muscles may become tense. During activation of the scalene muscles (fig 3), attached to the first rib far from the costotransverse joint, the anterior part of the first rib is raised by the scalenes, and any subluxation at the costotransverse joint is corrected allowing normal movement.

The function of the first rib was assessed after treatment by the same tests as on admission. After treatment, the CRLF test was normal in most of the symptom-free patients, and the cervical range of motion was also normalized. Only 12.6% of the patients were unresponsive to treatment and retained signs of cervical motion pathology.

It has been postulated that subluxation of the first rib at the costotransverse joint might irritate of the nerve roots C8 and T1 and the stellate ganglion, thus explaining the predominantly ulnar symptoms and the symptoms resembling those encountered in RSD.[8]

Reduced grip strength is common among TOS patients.[11,40] Reduced grip strength may be sympathetically mediated and may originate from irritation of the stellate ganglion. In the present study, grip strength was restored after therapy in 65% of those patients whose grip strength was reduced at admission. In the study by Novak et al,[12] conservative therapy relieved hand symptoms in patients without distal nerve compression.

In the present study, personal aids were prescribed to 16.1% of the patients to facilitate their daily activities. Such aids have also been recommended by others.[32]

Anxiety and tension are often features of TOS disorders and may be part of their etiology. They may also be one of the reasons for unsuccessful surgery.[4] In the present study, a multidisciplinary approach was used to detect the effect of depression and exhaustion on the symptoms. Thus, 6.9% of the patients needed psychologic or psychiatric consultation, and six patients were recommended retirement because of a primary psychiatric cause (table 6).

Cuetter and Bartoszek[41] and Lindgren[42] have reevaluated patients treated unsuccessfully with surgery for TOS; they found that in each case another disease or functional disturbance explained the patient's complaints. In the present series, retirement was recommended to 30 patients, with none of the recommendations being due to TOS (table 6). Most authors agree that surgery should be a last effort to relieve the patient's symptoms and avoid retirement. Still, there appears to be some eagerness to operate on these patients.[43] The decision to operate, however, is almost invariably based on clinical judgement without any objective findings.

Among the different operative procedures, scalenotomy seems to speed up patients' retirement,[44] and the results after surgery are no better than a placebo effect, a fact that is often overlooked. Recurrence after unsuccessful procedures may be a disabling and difficult problem for patients. This is extremely tragic in patients who have been found to have pulse changes in provocative positions in the absence of any other symptoms.[37] According to the present study, conservative therapy is the treatment of choice in TOS because it is safe and can be implemented as a self-treatment program. The treatment should aim at restoring the function of the upper thoracic aperture. Activation and strengthening of the scalene muscles attached to the first rib are essential. If symptoms are not abated despite restored function, the differential diagnosis should be reviewed. The fact that conservative treatment is tedious and relapses are common should not be considered a reason for surgical intervention. Surgery is a viable option only if there are signs of significant motor loss, atrophy, or vascular thrombosis. Treatment should be directed as specifically as possible to the structures involved, and a treatment program, such as the one presented herein, should be persistent and include long-term follow-up. Psychosocial aspects should always be taken into account. It is extremely important to evaluate the degree of disability that TOS symptoms cause in relation to the patient's life situation and psychosocial abilities. Because static load on the upper limbs probably produces some of the symptoms, we will soon be facing a generation of patients who have grown up with video games and computers seeking physiatric attention for repetitive motion disorders of the upper limbs.[45] Clearly, repetitive mechanical effort on the job will likewise eventually expose the anatomic weakness,[39] and physicians must be aware that the symptoms may be caused by "disabling" work and resist the temptation to resect anatomic structures for their treatment.

Acknowledgment: I am indebted to the staff of the Rehabilitation Ward of Kuopio University Hospital for their support during this long-term study. I am especially grateful to physiotherapists Eila Hyvönen, Ilkka Korhonen, Marja Pitkänen, and Taru Valta for their contribution to the practical implementation of the previously hypothetical therapeutic model. I would further like to thank Ismo Tiirikainen for his help during the computer phase of this work.

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