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## Clinical features and surgical treatment of combination of pronator teres syndrome and carpal tunnel syndrome

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**Objective:** To determine the effectiveness of surgical interventions aimed at decompression of the median nerve (MN) in the carpal tunnel and pronator teres canal, in combination with carpal tunnel syndrome (CTS) and pronator teres syndrome (PTS).

**Materials and methods:** The results of surgical treatment of patients with a combination of CTS and PTS were analyzed, a total of 20 observations. The analysis of the results was evaluated according to: the Boston Questionnaire (BCTQ), namely, symptoms severity scale - SSS (minimum 1 point, maximum 5 points) and functional severity scale - FSS (minimum 1 point, maximum 5 points), the Bishop Score, visual analogue scale (VAS).

**Results:** All operated patients (100%) experienced a significant regression of the main manifestations of the disease on the first day after the operation. Paresthesia in the fingers of the hand decreased, the sensitivity in the MN dermatome improved significantly, and sleep improved. The average indicators after surgery on symptoms severity scale (SSS) were 1.3 points, on functional severity scale (FSS) - 1.4 points, visual analogue scale - 2 points. The assessment of treatment results according to the Bishop Score in the postoperative period, that is, at the time of discharge (3 days after surgery), was an average of 10 points.

**Conclusions:** Decompression of the MN in the area of the carpal tunnel and pronator teres is an effective method of treatment for the combination of CTS and PTS. A positive effect in the form of a regression of pain syndrome, sensitivity disorders and an increase in strength in the hand is observed already in the early postoperative period. Scores on BCTQ and VAS improve by more than 50%.

**Key words:** pronator teres syndrome; carpal tunnel syndrome; neuropathy; median nerve

### Introduction

Median nerve (MN) compression is the most common (70%) of tunnel neuropathies and primarily occurs in the area of the carpal tunnel (CT). Manifestations of carpal tunnel syndrome (CTS) are observed at least once in a lifetime in 14% of the adult population. In addition to complaints, in 3.8% of individuals objective clinical signs are detected, in 2.7% they are confirmed by electrophysiological studies [1–3].

Characteristic manifestations of CTS are the occurrence of painful numbness in the 1st, 2nd, 3rd fingers and the radial half of the 4th finger and weakness of muscles of the thenar eminence on the hand. One of the main manifestations is sleep disturbance due to painful numbness in the fingers of the hand. As a result of impaired sensitivity of the fingertips and paresis of the thenar muscles, the ability to perform actions that require fine motor skills is reduced. After some time, atrophy of the thenar muscles, namely, the abductor pollicis brevis (APB), opponens pollicis (OP), flexor pollicis brevis (FPB) occurs. Electroneuromyography (ENMG), ultrasonography (US) of MN, and magnetic resonance

imaging of the hand are additional methods of diagnosis of CTS.

There are at least 5 anatomically narrow areas on the arm where the MN can be compressed. It is known that the second most frequent place of compression of the MN after the CT is the pronator teres area (6%), and the combination of compression at these two levels leads to the "double crash" syndrome [2].

Pronator teres syndrome (PTS) develops as a result of compression of the MN in the canal between the heads of the pronator teres (PT) muscle in the upper third of the forearm. The syndrome develops in individuals whose work or activity involves repetitive pronation-rotation movements of the hand and forearm, as well as after significant muscle overload of the pronators and flexors of the fingers. These activities are typical for musicians, dentists, athletes, agricultural workers, and carpenters. Also, PTS can occur after prolonged mechanical compression of the upper third of the forearm by the type of "honeymoon paralysis", local trauma, compartment syndrome, in the presence of a neoplasm in this area and in patients who are on dialysis for a long



time [4–6]. The morphological cause of PTS is thickening, spasm or compaction, most commonly of the lateral head/heads of the PT or the presence or occurrence of tendinous constrictions in the proximal heads of the muscle, causing MN compression.

Although PTS provokes symptoms similar to CTS [7–12], it has diagnostic features. With CTS, numbness is found only in the fingers and the distal part of the palm, while in the presence of PTS, in addition to the indicated dermatome, sensory disorders occur in the area of the thenar skin (**Fig. 1**), since the cutaneous palmar branch to this area departs from the MN proximal to the carpal tunnel and passes over the tunnel [13].

Expressive muscle weakness is not characteristic of PTS, but moderate paresis often occurs in *m. flexor pollicis longus*, manifested as paresis during isolated flexion of the distal phalanx of the 1st finger. Sometimes PTS appears as mild or moderate paresis in the radial part of *m. flexor digitorum profundus*, resulting in weakness when flexing the 2nd and 3rd fingers. In severe cases, due to paresis of the specified muscles, the symptom of "circle" can be observed, which consists in the impossibility of the 1st and 2nd fingers to form a "circle" when they are flexed and brought together (**Fig. 2**). The function of the PT is usually preserved, since the branch of the MN innervating the pronator departs from the MN more proximally in relation to the entrance to anatomical tunnel of the PT [8]. In the presence of PTS, a trigger tender point with reproduction of symptoms when pressed (Gainor test) [11] or percussion (Tinel's sign) in the area where the MN passes between heads of the PT is identified. In rare cases, the pronator-flexor test will be positive: pronation of the forearm with a tightly clenched fist results in increased pain.

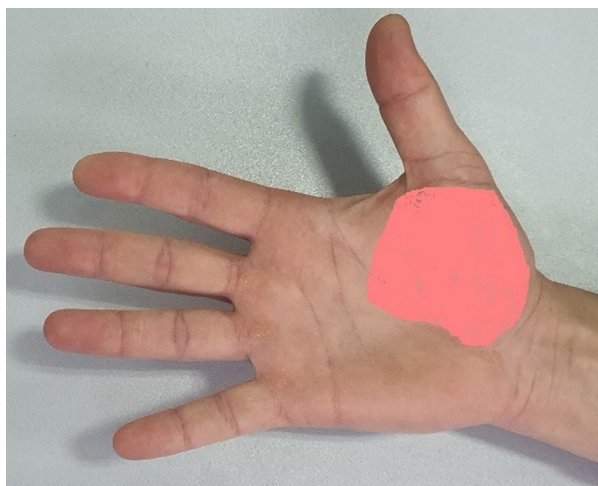
During electrophysiological diagnosis, the following changes may be detected: decreased motor and/or sensory conduction velocity at the "wrist - ulnar flexion" area when examining conduction along the MN. A sensitive marker is the absence of a sensory response when stimulating the MN at the ulnar flexion (relative sensitivity - 50%) [14]. Electromyography of the muscles innervated by the MN distal to the PT is a more sensitive method. Different degrees of deinnervation patterns with appearance of spontaneous activity of fibrillation potentials and positive sharp waves and a change in the morphology of motor unit potentials can be detected. Changes can usually be detected in the bellies of the *flexor digitorum superficialis*, which are attached to the 2nd and 3rd fingers, and in the *flexor palmaris longus*. If the interosseous nerve is involved, changes can also be found in the bellies of the *flexor digitorum profundus*, which provide the movement of the 2nd and 3rd fingers [14]. Despite the important role of electrodiagnostic studies in confirming the diagnosis, only in 10% of cases in patients with a characteristic clinical picture, the diagnosis is confirmed with the help of ENMG [12].

Ultrasonography (US) of MN in the area of CT, PT and surrounding soft tissues also plays an important role in the diagnosis. This research method makes it possible to detect/confirm MN compression, the presence of a

neoplasm in the area of the PT, and choose the optimal surgical approach [10].

Differential diagnosis should be made with neuropathy due to Struthers ligament compression, biceps aponeurosis hypertrophy, compression constriction of the superficial fingers flexor, thoracic outlet syndrome, brachial plexus injury, or cervical radiculopathy [8].

**Objective:** To determine the effectiveness of surgical interventions aimed at decompression of the median nerve (MN) in the carpal and pronator teres canal, in combination with carpal tunnel and pronator teres syndrome.



**Fig. 1.** Area of innervation of the palmar cutaneous branch of the MN. Hypoesthesia of this area is characteristic of median nerve compression in the pronator teres canal



**Fig. 2.** The "circle" symptom. When the patient tries to form a circle with the help of the thumb and index finger, only a drop-shaped opening can be formed (right) due to paresis of the anterior interosseous nerve (branches of the median nerve) and the development of paresis of the flexor pollicis longus and part of the flexor digitorum profundus

**The purpose of the study** is to improve the treatment outcomes of patients with combination of PTS and CTS.

### Materials and methods

#### Study participants

Patients with combination of CTS and PTS (n=20). Informed and voluntary written consent to participate in the study was obtained from all patients.

The research was approved by the Ethics and Bioethics committee at Vinnytsia National Pirogov Memorial Medical University (Minutes №158).

#### Inclusion and exclusion criteria

Patients with combination of PTS and CTS were included in the study (**Table 1**).

#### Characteristics of the group

There were 2 (10%) men and 18 (90%) women among those operated on. The patients ranged in age from 35 to 76 years, with an average age of 51 years. The mean duration of the disease was 11 months. In 13% of patients, an average of 5 months before surgery, there was a fracture of the forearm bones, after which complaints gradually developed that forced them to consult a doctor, 30% of patients reported recurrent microtraumatization of the palm area, in 26% of patients, daily activities and/or profession associated with pronation movements in the forearm. All patients pointed to physical exertion of the hands as a probable cause of the development of the disease.

#### Study design

The study is retrospective. The results were evaluated using the Boston Carpal Tunnel Questionnaire (BCTQ), namely symptoms severity scale (SSS, minimum – 1 point, maximum – 5 points) and functional severity scale (FSS, minimum – 1 point, maximum – 5 points). The Bishop Score was also used, which allows you to assess satisfaction with the results, the degree of improvement, the severity of residual symptoms, working capacity, leisure time, muscle strength, and sensitivity. Severity of pain syndrome in the hand and forearm was assessed using the visual analogue scale (VAS). Postoperative follow-up was 6 months.

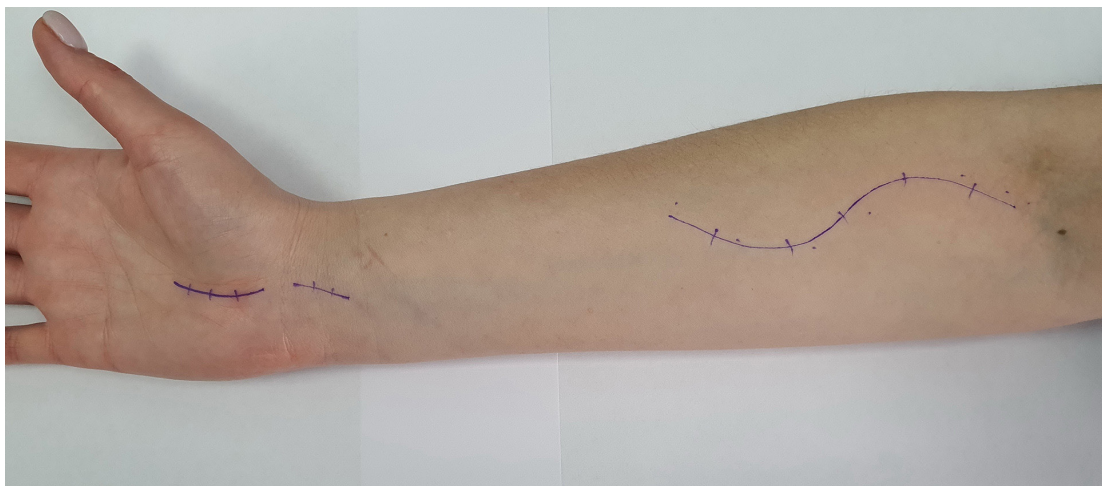
Patients with CTS in combination with PTS were operated on using a technique that involves decompression of the MN both in the PT and in the CT area from two approaches in a single stage.

Surgery is performed under general anesthesia. The patient is positioned on the back with the arm retracted to 90° and placed on the additional table. Exsanguination is carried out with a compression tourniquet under a pressure of 250 mm Hg, which enables full visualization of all structures, fast detection of the MN and its mobilization. An S-shaped skin and soft tissues incision is made in the upper third of the forearm, with a transition to the middle third (**Fig. 3**). The median vascular bundle is isolated, preserving the subcutaneous nerve fibers. During the dissection of the skin, subcutaneous fat, and superficial fascia of the forearm, the branches of the lateral and medial cutaneous nerves should be preserved. The intermuscular space between the brachioradialis muscle and the radial flexor of the wrist is separated. In the depth of the wound, deeper than the radial artery on one side and the sensory branch of the radial nerve on the other, the distal PT tendon is found, which is attached to the middle and distal part of the radius. The tendon is intersected with Z-shaped incision (**Figures 4 and 5**). The muscular part of the PT is left unintersected. This technique is aimed at lengthening the PT and preventing MN compression in the postoperative period.

In the proximal part of the wound, the space between the PT and the brachioradialis muscle is separated. The aponeurosis of the biceps muscle on the forearm is partially or completely intersected. Under the vascular bundle (brachial artery bifurcation area) in the depth of the cubital fossa, the MN is defined, covered and compressed by the PT in the interhead space (canal). Using scissors and electrocoagulation forceps, the radial head of the PT is intersected, contributing to the release of MN (**Figures 6 and 7**). The latter is additionally mobilized distally and proximally from the surrounding tissues and vascular structures, which are tipped over distally up to the level of the origin of the anterior interosseous nerve.

**Table 1.** Criteria for inclusion and exclusion of patients with combination of carpal tunnel and round pronator syndromes depending on diagnostic findings

Diagnostic criterion	Inclusion criteria	Exclusion criteria
Pain	It is localized on the anterior surface of the forearm, in the 1st, 2nd, 3rd and 4th fingers, the radial surface of the palm; nocturnal and daytime	It is localized in the hand and fingers with radiation in the proximal parts of the upper limb
Motor function	Impaired function of <i>flexor pollicis longus</i> , <i>flexor digitorum profundus</i> muscles	Impaired function of <i>m. opponens pollicis</i>
Sensitive disorders	Sensory disturbance in fingers 1, 2 and 3, on the radial surface of the 4th finger, palmar surface of the hand above the thenar muscles	Sensory disturbance only in the autonomous innervation zone of the median nerve on the hand and fingers (1st, 2nd and 3rd fingers, radial surface of the 4th finger)
Provocative tests in forearm pronation	Positive	Negative
Tinel's sign	Positive in the projection of the median nerve in the area of the carpal tunnel, the upper and middle third of the anterior surface of the forearm	Positive in median nerve projection proximal to the pronator teres area



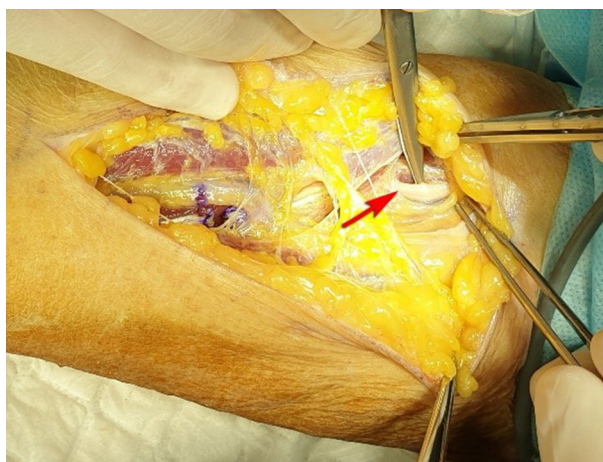
**Fig. 3.** Access landmarks for median nerve decompression in the region of carpal tunnel and pronator teres



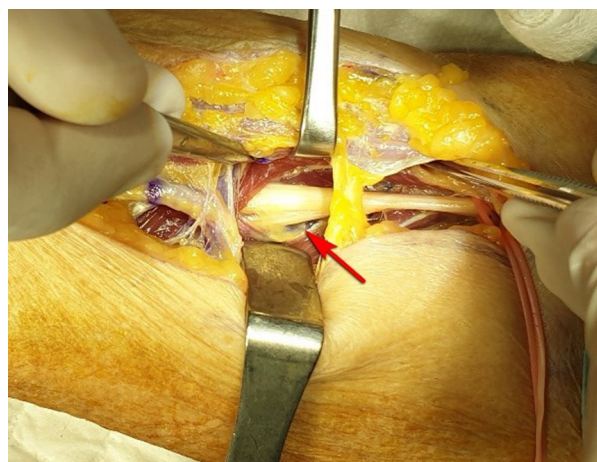
**Fig. 4.** The line of intersection of the tendon of the deep head of the pronator teres with transition to the periosteum of the radius



**Fig. 5.** The tendon of the deep head of the pronator teres is intersected



**Fig. 6.** Median nerve compression in the pronator teres region. The compression area (entrance to the canal of pronator teres) is indicated by an arrow



**Fig. 7.** Median nerve after decompression. The arrow indicates the edge of the dissected lateral head of the pronator teres and the branch of the anterior interosseous nerve



**Fig. 8.** Median nerve compression. Carpal tunnel entry area



**Fig. 9.** Median nerve after carpal ligament dissection

Decompression of the MN in the PT area, supplemented by nerve decompression in the CT area, is performed using the classic or endoscopic technique (**Figures 8 and 9**).

**Statistical analysis**

Wilcoxon t-test - a non-parametric analogue of the paired Student's test (t-test for dependent samples) was used to compare the condition of patients before and after MN decompression. The critical level of statistical significance when testing all hypotheses (p) was taken to be 0.05.

**Results and discussion**

A total of 20 surgical interventions for the combination of CTS and PTS were performed. All operated patients noted a significant regression of basic manifestations of the disease on the first day after surgery. Paresthesias in the fingers of the hand decreased, sensitivity in the MN dermatome and sleep improved significantly.

The mean scores on the SSS, FSS, and VAS scales after surgery were statistically significantly lower than before surgery (**Table 2**).

The assessment of treatment outcomes according to the Bishop Score at the time of discharge (3 rd day after surgery) averaged 10 points.

Six (31.6%) patients had minor discomfort in the area of the forearm scar in the postoperative period. All patients did not experience difficulties in daily activities and severe residual symptoms, pain sensations were unexpressive and did not affect daily activities. The pathognomonic symptoms of PTS also regressed significantly: numbness in the thenar region decreased, strength increased in the the flexor pollicis longus and part of the flexor digitorum profundus. Decompression of the MN in the area of the CT and PT is highly effective in restoring the patient's functional status.

The presence of a postoperative wound on the forearm did not affect the duration of rehabilitation and return to previous work. In no case was there a decrease in the amplitude of pronation movements of the hand on the side of the intervention.

Given the relative difficulty of accessing the MN in the upper third of the forearm, special attention should be paid to isolating the sensitive branch of the radial nerve, radial artery, anterior interosseous nerve, and lateral vena cephalica to avoid damage to these structures.

**Table 2.** Average SSS, FSS, and VAS scores before and after median nerve decompression at the level of the carpal tunnel and pronator teres

Scale scores, point	Before decompression of MN	After decompression of MN (in 7 months)	Δ, %	p
SSS	3,2±0,56	1,3±0,3	↓ 58	<0,01
FSS	3,1±0,73	1,4±0,48	↓ 56	<0,01
VAS	6,6±1,85	2±1,08	↓ 70	<0,01

### Conclusions:

1. MN decompression in the area of the CT and PT is an effective method of treating a combination of CTS and PTS. A positive effect in the form of a regression of pain syndrome, sensitivity disorders and an increase in strength in the hand is observed already in the early postoperative period. Scores on BCTQ and VAS improve by more than 50%.

2. When examining patients with suspected of CTS, the signs of MN damage above the level of the CT should be considered: numbness of the palmar surface of the thenar, positive provocative tests in the area of the PT, decreased function of the the flexor pollicis longus ("circle" symptom), ultrasonography and ENMG findings suggesting the presence of compression in the upper and middle third of the forearm.

3. It is necessary to conduct a study with the involvement of patients with complaints and additional findings, which indicate the combination of CTS and PTS, and randomization of patients to those who will undergo CT decompressed and those who will additionally undergo MN decompression in the area of the PT. Comparison of surgical outcomes in these groups will reveal the role of MN decompression on the forearm in the PT area.

### Disclosure

#### *Conflict of interest*

The authors declare no conflict of interest.

#### *Ethical approval*

All procedures performed on patients during the study comply with ethical standards of institutional and national ethics committees, and the Declaration of Helsinki (1964) and its amendments or similar ethical standards.

#### *Informed consent*

Informed and voluntary written consent to participate in the study was obtained from each patient.

#### *Funding*

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