

# Provocative tests used in the diagnosis of carpal tunnel syndrome

## Testy prowokacyjne stosowane w diagnostyce zespołu cieśni nadgarstka

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### Key words

carpal tunnel syndrome, diagnosis, provocative test, sensitivity, specificity

### Abstract

The carpal tunnel syndrome (CTS) is the most often diagnosed compressive neuropathy of the upper limb. As a result of the changes within the tunnel of the median nerve, the disease is associated with hypersensitivity to some external factors such as: an increase in pressure within the carpal tunnel, direct or indirect pressure on the wrist level, hypoxia. These factors are used in provocative tests. The aim of this article is to make a distinction between functional test's classifications used in the CTS diagnosis, depending on the method of ailment provocation. Different modifications used in common tests and their average sensitivity and specificity are also presented. Carpal tunnel syndrome should be diagnosed clinically; although electro-diagnostic studies are a standard method of establishing the diagnosis, they do have limitations. Clinical diagnostic skill must be reinforced by a valuable provocative test: the Provocative Test, the Phalen test + mCCT, Tinel's sign, Phalen's and reverse Phalen's test, Durkan Carpal Compression Test (mCCT). There are also tests, which, due to their low sensitivity and specificity, be not applied in the CTS diagnostics. Provocative tests are more easily performed than electro-diagnostic studies and are the most appropriate diagnostic tools in the ambulatory setting. Provocative tests are commonly needed for establishing the diagnosis for treatment, screening and determining aetiology. To improve the efficiency of provocative tests, we should apply univocal standards for their performance and interpretation. A combination of tests might be more powerful than a single test in establishing the diagnosis. Taking medical history and performing physical examination should be the primary methods of diagnosing CTS. The combination of hand diagram, questionnaires, abnormal sensibility and positive provocative tests will provide a diagnostic tool for CTS with high sensitivity and specificity. The addition of nerve conduction studies is unnecessary in most cases.

### Słowa kluczowe

zespół cieśni nadgarstka, diagnostyka, testy prowokacyjne, czułość, specyficzność

### Streszczenie

Zespół cieśni nadgarstka (ZCN) jest najczęściej rozpoznawaną neuropatią uciskową kończyny górnej. Na skutek zmian w obrębie kanału nadgarstka nerw pośrodkowy wykazuje nadwrażliwość na działanie niektórych czynników zewnętrznych takich jak: wzrost ciśnienia w kanale nadgarstka, bezpośredni lub pośredni ucisk, niedotlenienie. Czynniki te są wykorzystane w testach prowokacyjnych. Celem niniejszej pracy jest dokonanie podziału, przedstawienie różnych modyfikacji oraz średnich wartości czułości i specyficzności testów prowokacyjnych powszechnie stosowanych w diagnostyce ZCN. ZCN powinien zostać potwierdzony klinicznie i chociaż badania elektrodiagnostyczne są traktowane jako standardowa metoda potwierdzająca obecność zespołu posiadają pewne ograniczenia. Diagnoza kliniczna musi być potwierdzona przez wartościowe testy prowokacyjne do których zaliczamy: *provocative test*, test Phalena + manualny test uciskowy Durkana, test Tinel, test Phalena i odwrócony test Phalena oraz manualny test uciskowy Durkana. W artykule wskazano testy, które ze względu na niskie wartości czułości i specyficzności lub niejasny sposób wykonania i interpretacji nie mają zastosowania w diagnostyce ZCN. Testy prowokacyjne są łatwiejsze w wykonaniu i bardziej dostępne niż badania elektrodiagnostyczne i dlatego traktowane są jak najodpowiedniejsze ambulatoryjne narzędzie diagnostyczne. Są one powszechnie wymagane do potwierdzenia diagnozy, monitorowania przebiegu i ustalenia etiologii choroby. Dla poprawy skuteczności testów prowokacyjnych powinny zostać ustalone jednoznaczne standardy dotyczące sposobu ich wykonania i interpretowania, a zastosowanie kilku z nich może zwiększać trafność diagnozy. Wykorzystanie historii choroby i badania klinicznego powinno być zasadniczą metodą wykorzystywaną w diagnostyce ZCN. Połączenie wyników uzyskanych na podstawie diagramów, kwestionariuszy, stwierdzenie nieprawidłowego progu czucia i pozytywnych wyników testów prowokacyjnych jest narzędziem diagnostycznym o wysokiej wartości czułości i specyficzności. Wykonanie badań elektrodiagnostycznych jest zbędne w wielu przypadkach.

## INTRODUCTION

Carpal tunnel syndrome (CTS) is the most frequently diagnosed, treated and described compression neuropathy of the upper limb. It is estimated that its prevalence is 0.1% in general population and that it occurs in 15% of persons with an increased risk for CTS.

The disease involves a disturbance in the relation of median nerve volume and volume of the carpal tunnel, which the median nerve passes through. The majority of authors addressing the problem of CTS share the opinion that a reduction in carpal tunnel volume or an increase in pressure within the tunnel is the causative factor of the disease. When the pressure is high, the median nerve is pressed towards the flexor retinaculum of the hand located above the median nerve. Long-term increase of pressure and direct tension on the median nerve lead to nerve ischaemia, distally from the site of tension resulting in nerve damage in a form of intra-nerve scarring. Blood flow disturbances induce oedema within the intra-nerve space, which aggravates compression of nerve fibres. In CTS, restriction of venous blood outflow and arterial blood supply at the carpal tunnel region also occurs thus impairing axoplasm transport and resulting in clinical manifestations of nerve compression. Reduction in blood flow due to external compression is considered the main factor leading to occurrence of peripheral neuropathy.<sup>1-16</sup> Clark et al.<sup>17</sup> proved in an experimental model that a reduction in nerve diameter of 8% results in 50% blood flow reduction, and a 15% decrease in diameter causes blood flow reduction by as much as 80%.

As a result of the above-described changes, the median nerve demonstrates hypersensitivity to influence of extrinsic factors such as: rise in the pressure inside the carpal tunnel, direct or indirect tension, impairment of limb circulation, traction of the nerve trunk. These factors are used in provocation manoeuvres enabling occurrence or

aggravation of the characteristic signs accompanying compression of the median nerve at the level of carpal tunnel. Provocation tests used in the diagnosis of CTS should create possibly greatest unfavourable anatomical relations in the vicinity of the median nerve and thus induce paresthesias.

## CLASSIFICATION OF PROVOCATIVE TEST USED IN THE DIAGNOSIS OF CST

Provocation tests used to establish the diagnosis of CTS aim at eliciting or aggravating pain and paresthesiae within the region innervated by the median nerve in a situation when it is compressed at the level of the carpal tunnel. This effect can be achieved by the following factors:

- 1) increase in pressure within the carpal tunnel (Phalen's test, reverse Phalen's test, lumbrical provocation);
- 2) direct mechanical pressure on the median nerve at the level of the carpal tunnel (Durkan Carpal Compression Test – mCCT, Pressure Provocative Test – PPT, Tinel's test);
- 3) „action” and pressure onto the median nerve by stretching the transverse ligament of the wrist (Provocative Test);
- 4) impairment of blood flow in the upper limb resulting in ischaemia or compression of the median nerve that is particularly sensitive to the effects of the above factors (tourniquet test – fr. *Tourniquet Gillat*, Volume Provocation Test (VPT), hand elevation test);
- 5) use of ultrasound wave;
- 6) stretching of the nerve trunk or the nerve roots of the median nerve (Upper Limb Tension Test – ULTT, Tethered Median Stress Test);
- 7) use of two of the above provocative manoeuvres – combined tests (Phalen test + mCCT, Phalen test + tourniquet test).

## DESCRIPTION OF METHODOLOGY OF APPLICATION AND MODIFICATIONS OF THE TESTS

### Tests increasing carpal tunnel pressure

#### Phalen test

Background:

Flexion increases carpal tunnel pressure. The median nerve is subjected to the effects of increased pressure that induces or aggravates the symptoms<sup>12,14,15,18,19</sup>.

Methodology:

Patient places the elbow on a table, the forearm remains perpendicular to the table surface, while the wrist falls downwards with the weight of the hand up to complete flexion and remains flexed for 1 minute<sup>2,4,16,18,20-23</sup>.

Variants:

- patient actively, but without excessive force, positions his wrist at maximum flexion<sup>12,15,24</sup>,
- the examiner flexes patient's wrist and holds it at palmar flexion (for 30-40 seconds)<sup>1,3,5,7,13,18,25,26</sup>,
- patient maintains palmar flexion of the hand by exerting tension of dorsal parts of the hands onto each other<sup>18,27,28</sup>.

Positive test result:

Occurrence or aggravation of paresthesiae within the region supplied by the median nerve. Time delay to occurrence of symptoms may be noted<sup>18</sup>.

Remarks:

The result can be falsely negative in patients with restriction of carpal flexion. Test duration longer than 1 minute may induce symptoms even in a healthy hand<sup>22</sup>.

#### Reverse Phalen test

Background:

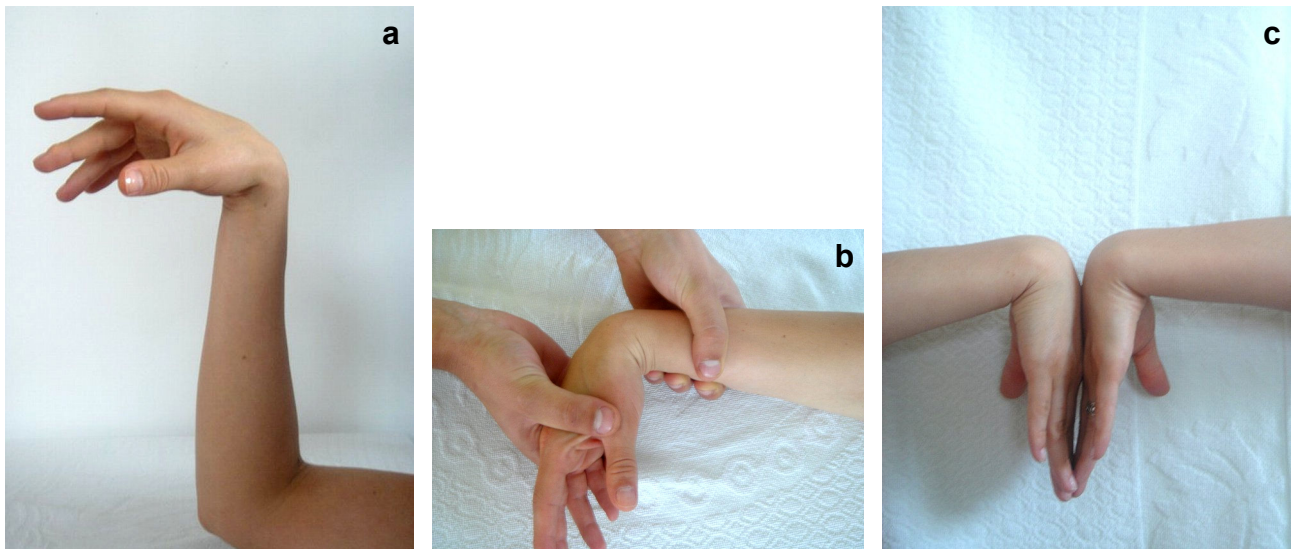
Extension also increases carpal tunnel pressure<sup>14,15,18,19</sup>.

Methodology:

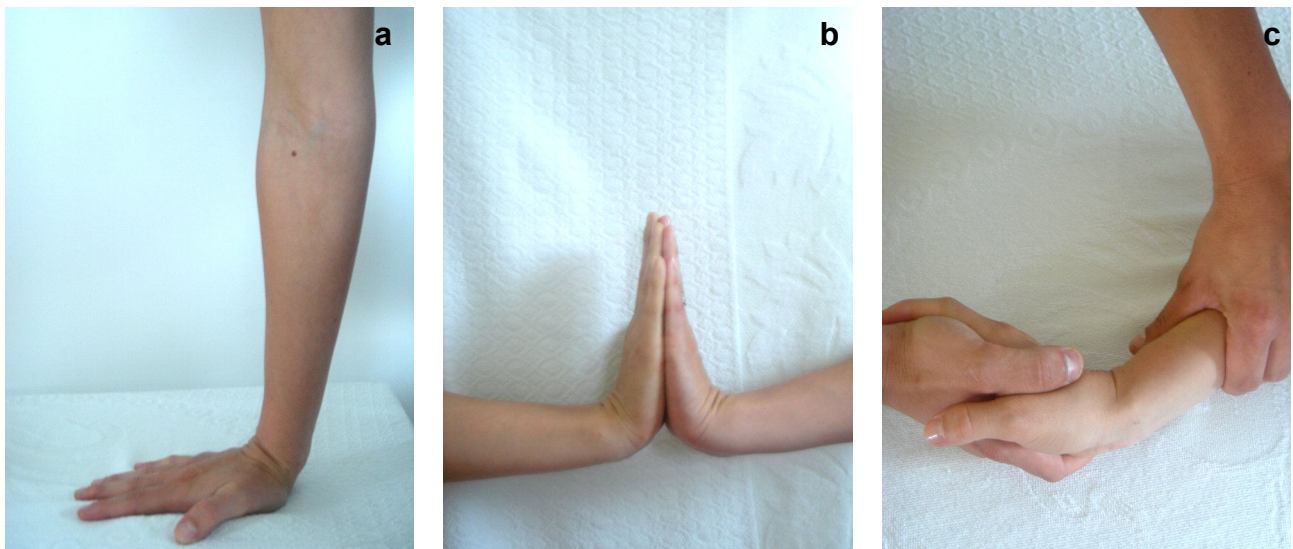
Patient actively extends the wrist and the fingers for 2 minutes<sup>18</sup>.

Variants:

- patient places palmar part of the



**Photo 1 a-c**  
Different variants of the Phalen test



**Photo 2 a-c**  
Different variants of the reverse Phalen test

- hand on a table while simultaneously augmenting wrist extension<sup>18,23</sup>,
- patient places the palms together holding the elbows elevated and actively stretches the wrists (the hands in the prayer-like position)<sup>4,15,23,27</sup>,
  - wrist extension can also be passive – performed by the examiner<sup>3,13</sup>.

**Positive test result:**

Occurrence or aggravation of paresthesiae within the region innervated by the median nerve after 120 or 60 seconds of the test<sup>13</sup>.

**Remarks:**

The result can be falsely negative in patients with restriction of wrist extension.

**Stimulation of the median nerve by means of the lumbrical muscles (lumbrical provocation)<sup>18</sup>**

**Background:**

The lumbrical muscles can be displaced towards the carpal tunnel during finger flexion. It is considered possible that this may induce an increase in pressure inside the carpal tunnel.

**Methodology:**

Patient is asked to make a fist for a period of time of 1 minute.

**Positive result:**

Occurrence or aggravation of symptoms within the region innervated by the median nerve.

**Tests using direct mechanical pressure on the median nerve**

**Durkan Carpal Compression Test (mCCT)**

**Background:**

Direct, additional tension on the median nerve aggravates the symptoms. This results from the fact that CTS is induced by an increase in pressure in the region of the carpal tunnel, which leads to local nerve is-



**Photo 3**  
**Performance of the Durkan Carpal Compression Test (mCCT)**

chaemia. When carpal tunnel pressure is increased, median nerve signs are faster manifested, as the nerve has a reduced threshold for additional external compression.

**Methodology:**

Patient remains in a sitting position, the elbow joint at angle of 0° to 30°, forearm positioned in supination, the wrist and hand in a neutral position. The therapist places the thumbs over the proximal part of the wrist flexion line (above the proximal edge of the transverse ligament of the wrist), over the median nerve and exerts a pressure of approximately 3 kg (6 pounds) for 30 seconds<sup>12,16,18,20,23,26,29,30</sup>.

**Variants:**

- originally, the test was performed using a tool consisting of a rubber pump placed in the region of flexor retinaculum and connected to a manometer; the examiner exerted a pressure on the median nerve by pressing the pump with his fingers for 30 seconds; the pressure was 150 mmHg<sup>29</sup>,
- pressure force is 10 N/cm<sup>2</sup>,<sup>16</sup>
- the thumb can be used to compress the median nerve; in this case, duration of the test is 60 seconds<sup>13</sup>.

**Positive result:**

Occurrence or aggravation of paresthesiae within the region supplied by the median nerve.

**The Pressure Provocative Test (PPT)<sup>18,30,31</sup>**

**Background:**

As in case of the manual Durkan Carpal Compression Test.

**Methodology:**

The examiner puts a 1-inch wide tourniquet over the proximal part of the carpal tunnel. Patient's arm is laid on a table, forearm in supination, the wrist in a neutral position. The tourniquet is subsequently filled with air up to the pressure of 150 mmHg. Test duration is 30 seconds.

**Positive result:**

Occurrence or aggravation of paresthesiae within the region innervated by the median nerve.

**Tinel Test (Hoffman and Tinel test)**

**Background:**

Direct, mechanical compression of the median nerve aggravates the symptoms.

**Methodology:**

Patient in sitting position, the elbow joint at flexion of 0° to 30°, the forearm in supination, patient's wrist positioned in a neutral position. The examiner, with the pulp of his index or middle finger, delicately taps the region of the carpal tunnel along the course of the median nerve between the tendon of the radial

flexor of the wrist and the palmar muscle long, close to the flexor plica of the wrist<sup>1,3-5,7,12-16,18,21,23,24,26,28,29,32</sup>.

**Variants:**

- tapping is performed from the proximal to distal edge of the transverse ligament of the wrist<sup>18,23</sup>,
- tapping is performed a total of 6 times from the distal to proximal edge of the transverse ligament of the wrist<sup>20</sup>,
- tapping using neurological hammer for examination of reflexes may increase test sensitivity<sup>13,18</sup>.

**Positive result:**

Occurrence of paresthesiae or sensation of current flow to the distal parts of the median nerve.

**Remarks:**

The test can also be used to assess the course of regeneration of the median nerve<sup>18</sup>.

It can be used in mild CTS<sup>18</sup>.

**Tests with compression of the median nerve by the transverse ligament of the wrist**

**Provocative Test<sup>33</sup>**

**Background:**

Mechanical compression of the median nerve by stretched transverse ligament increases intensity of the symptoms.



**Photo 4 a i b**  
**Performance of the Provocative Test**



**Methodology:**

Patient's forearm is positioned in pronation. The wrist is in neutral position or in slight extension ( $5^\circ$  -  $7^\circ$ ). During performance of the test, patient's extremity should be at possibly maximal relaxation. The examiner places „partially flexed fingers” – the 2<sup>nd</sup> and 3<sup>rd</sup> – of one hand on the palmar surface of patient's hand over the distal half of the first metacarpal bone. The index and the median finger of the other examiner's hand is positioned on the palmar surface of the hand close to the pisiform and triquetral bones. The thumbs are situated on each other and are placed on the dorsal surface of the hand close to the semilunar bone (located at the prolongation of the middle finger). The therapist begins to exert a pressure in the dorsal direction (towards dorsal flexion of the hand) using the 2<sup>nd</sup> and 3<sup>rd</sup> finger (of both hands) while simultaneously pushing the semilunar bone towards the palmar direction (“attempting to open the carpal tunnel or stretch the transverse ligament of the wrist”). Moderate, constant pressure is maintained for 60 seconds.

**Positive result:**

Occurrence or augmentation of sensation of pain, tingling or numbness within the 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> or the radial half of the 4<sup>th</sup> finger.

**Tests inducing blood flow reduction in the upper limb thus leading to ischaemia or compression of the median nerve load pressure**

**Tourniquet test (Tourniquet Gillat)**<sup>1,7,13,15,18,23,24</sup>

**Background:**

Increasing the pressure in the tourniquet above the systolic blood pressure subjects the median nerve to ischaemia and aggravation of symptoms.

**Methodology:**

The test involves filling of the tourniquet placed around the arm with air – a pneumatic belt – to a pressure above the systemic systolic blood pressure.

**Variants:**

- intra-tourniquet pressure is 250 mmHg<sup>13</sup>,
- intra-tourniquet pressure is 150 mmHg<sup>15</sup>.

**Positive test result:**

After 60 seconds, paresthesiae in the region of median nerve innervation occur or are aggravated.

**Remarks:**

The result can be falsely positive if strong paresthesiae and pricking sensation are not limited only to the median nerve innervation but occur in the whole extremity (as a result of compression of all the nerves of the limb)<sup>11</sup>.

**The Volume Provocation Test (VPT)**<sup>11</sup>

**Background:**

Increasing the pressure in the tourniquet to slightly below the value of diastolic blood pressure reduces venous return from the limb. Inflow of the arterial blood is compromised to a lesser extent, which leads to forearm and hand oedema thus provoking occurrence of neurological signs (distal venous pooling can induce symptoms).

**Methodology:**

The test involves filling a tourniquet placed around the upper part of the arm to a pressure of 15 mmHg below the diastolic pressure and maintenance of this pressure for 4 minutes.

**Positive result:**

After 4 minutes, paresthesiae in the region supplied by the median nerve occur or are aggravated (night-time symptoms are replicated).

**Hand elevation test**<sup>18</sup>

**Background:**

It is not precisely explained but elevation of the hand can impair blood circulation in the upper extremity and elicit signs of median nerve ischaemia.

**Methodology:**

The patient elevates the arm with the elbow and the scapula in a relaxed position and maintains the position for 2 minutes.

**Positive result:**

Paresthesiae in the region innervated by the median nerve occur.

**Remarks:**

The efficacy of the test may be decreased because of possible occurrence of symptoms induced by com-

pression of other nerves (thoracic outlet syndrome).

**Test using an ultrasound wave**

**The ultrasound provocative test**<sup>23</sup>

**Background:**

The mechanism of median nerve stimulation by ultrasound waves is unknown.

**Methodology:**

Therapist stimulates the median nerve over the carpal tunnel over the 4th finger line using an ultrasound wave with a power of 1 W/cm<sup>2</sup>, 1.5 W/cm<sup>2</sup>, 2 W/cm<sup>2</sup>.

**Positive test result:**

Paresthesiae, numbness, discomfort or pain in the region innervated by the median nerve occurs.

**Tests with nerve trunk stretching**

**Tension test for the median nerve (Upper Limb Tension Test – ULTT)**<sup>26,32</sup>

**Background:**

Stretching of a nerve root or its trunk in cases where it is irritated, induces aggravation of symptoms.

**Methodology:**

The patient is in a supine position on his back, the therapist displaces the affected extremity sequentially towards borderline positions: 1 – lowering of the scapula, 2 – abduction of the arm, 3 – supination of the forearm and wrist extension, 4 – external arm rotation, 5 – extension of the elbow, 6 – rotation of the neck in the contralateral direction and subsequently towards the tested limb. The patient is asked to observe the symptoms during the manoeuvre.

**Positive test result:**

Occurrence of any of the below described symptoms: 1 – symptoms usually occurring in every-day life are reproduced during the test; 2 – differences in elbow extension greater than 10° as compared to the contralateral side at the end of the whole sequence of movements; 3 – contralateral rotation aggravates symptoms, rotation towards the tested extremity reduces symptom intensity.

Remakrs:

By eliciting tension on the nerve trunk, we do not know precisely, which of the structures constitutes the source of dysfunction. The result can also be positive when stimulating the median nerve proximally with regard to the carpal tunnel.

### Tethered Median Stress Test<sup>18,35</sup>

Background:

Stretching of the nerve trunk aggravates the symptoms in cases where the nerve is irritated.

Methodology:

The median nerve is subjected to passive stretching by supination in the wrist and extension of the index finger by the examiner, who holds the distal phalanx of the finger.

Positive test result:

Occurrence of pain in the proximal palmar part of the forearm.

### Mixed tests

#### The Phalen test + Durkan manual carpal compression test (mCCT)<sup>12,18,22,23</sup>

Background:

Increase of pressure in the carpal tunnel occurring in the flexed position combined with an additional direct compression of the median nerve by the therapist's hands aggravates local nerve ischaemia to a greater extent than during any of the separately performed: Phalen or Durkan tests. The combination of the tests leads to abrupt aggravation of symptoms.

Methodology:

The patient places the elbow on the table, the forearm is positioned perpendicularly to the table surface, the wrist is falling passively with hand's weight. Simultaneously, the therapist places his thumbs in the region of the proximal wrist flexion line and exerts a uniform pressure over the wrist.

Variants:

- patient's forearm is positioned in supination, the elbow joint is extended, the wrist flexed to an angle of 60°; in this position, the therapist compresses the wrist region using his thumbs<sup>12,23</sup>.

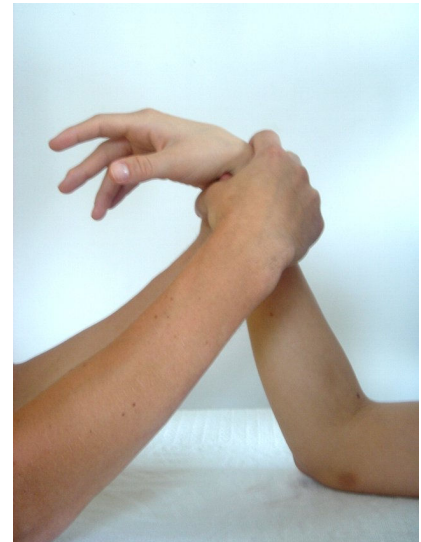


Photo 5 a i b

Performance of the Phalen test and the Durkan Carpal Compression Test (mCCT)

Positive test result:

Paresthesiae in the region innervated by the median nerve occur within 30 seconds<sup>25</sup>. If symptoms appear within up to 20 seconds, test sensitivity is 82% and specificity – 99%<sup>12,22</sup>.

#### The Phalen test + Tourniquet Gillat test<sup>13</sup>

Background:

Increase of pressure in the carpal tunnel occurring in the flexed position combined with increased pressure in the tourniquet above the systolic blood pressure sensitizes the median nerve to ischaemia and aggravation of symptoms.

Methodology:

The therapist fills the tourniquet placed over the arm with air to a pressure above the systolic pressure and subsequently positions the upper patient's limb in a position used in the Phalen test for a period of 30 seconds.

Variants:

- intra-tourniquet pressure is 250 mmHg.

Positive test result:

Paresthesiae in the region innervated by the median nerve occur.

It is noteworthy to mention that, after having performed any of the provocation test, it is useful to observe, how patients try to alleviate

the symptoms of paresthesiae and numbness. It was found that in patients with CTS, the so-called "flick" sign can be observed<sup>18,36,37</sup>.

Background:

Patients describe that they flick, shake their hand to decrease the intensity of symptoms.

### ASSESSMENT OF SENSITIVITY AND SPECIFICITY OF PROVOCATIVE TESTS USED IN THE DIAGNOSIS OF THE CTS

Sensitivity is an index representing the number of positive results for 100 patients with confirmed CTS (Table 1, column 3). This parameter describes the power to detect persons with CTS. The test is sensitive if there are few persons with falsely negative results.

Specificity is reported as the number of negative test results for 100 patients, who were not diagnosed with CTS (Table 1, column 5). This parameter describes the capability of a test to detect healthy persons. A test is considered specific when the number of persons with falsely positive results is small. Studies involving a healthy, symptom-free control group can yield falsely high specificity, because negative results can be anticipated for the majority of tests in a group of persons who do

not experience symptoms. Specificity may be defined as the number of negative test results for 100 patients, in whom CTS signs are present but EMG yields negative results (Table 1, column 6). In this situation, specificity of the test may be markedly reduced, as some of these patients might really have (which is highly probable) CTS.

Tests with sensitivity and specificity higher than 50% are classified as potentially reliable and are used to establish the diagnosis of CTS<sup>18</sup>. In the Table 1, 2 and 3, these tests were bolded.

Among all the tests, the Provocative Test<sup>33</sup> proved to be most sensitive (sensitivity and specificity = 98%); however this test was evaluated only in one study, where all the remaining tests also proved to have high sensitivity and specificity.

The Phalen test + mCCT showed very good results confirmed in two publications; the best result in the table 2 – 10 points and sensitivity – 82% and specificity – 99%<sup>22,23</sup>, as well as a very good result in the table 1 – sensitivity of 80% and specificity of 90% and 92%.

Further, the Phalen test combined with the tourniquet test were found to be very good tests but only in the group of patients undergoing dialysis (92% and 95%)<sup>38</sup>. A markedly worse result was presented in another publication (80% and 17%)<sup>13</sup>.

The following tests: mCCT, the Phalen test, the reverse Phalen test, the Tinel test, the tourniquet test and the PPT also showed good results (the last two tests had similar results).

Results reported for the Tethered Median Stress Test in two publications are different. The study involv-

**Table 1**

Mean sensitivity and specificity of carpal tunnel syndrome provocative tests described by MacDermid et al.<sup>18</sup>

Test	Number of tested cases	Number of persons in the control group	Sensitivity [%]	Specificity [%] (symptom-free group)	Specificity (patients with symptoms and negative EMG result)	Specificity [%] (all studied persons)
Phalen	3218	1637	<b>68</b>	<b>86</b>	<b>65</b>	<b>73</b>
Reverse Phalen	640	360	<b>54</b>	<b>86</b>	<b>55</b>	<b>78</b>
Lumbrical provocation	159	175	48	92	71	81
MCCT (Durkan)	1985	1082	<b>64</b>	<b>88</b>	<b>64</b>	<b>83</b>
Tinela	2640	1614	<b>50</b>	<b>84</b>	<b>65</b>	<b>77</b>
Tourniquet Gilliat	306	316	<b>59</b>	<b>68</b>	26	<b>61</b>
Tethered median stress	254	92	48			76
Phalen + mCCT	190	238	<b>80</b>	<b>90</b>		<b>92</b>
Flick sign	5036	3854	47		51	62

**Table 2**

Values of sensitivity and specificity of carpal tunnel syndrome provocative tests described by various authors<sup>12,13,26,30,33,35,38</sup> – author's analysis

Test	Number of tested cases	Number of persons in the control group	Sensitivity [%]	Specificity [%] (symptom-free group)	Specificity (patients with symptoms and negative EMG result)	Specificity [%] (all studied persons)
Phalen <sup>33</sup>	60	41	<b>93</b>	<b>93</b>		
Phalen <sup>26</sup>	28	52	77			40
Reverse Phalen <sup>33</sup>	60	41	<b>88</b>	<b>93</b>		
mCCT (Durkan) <sup>33</sup>	60	41	<b>90</b>	<b>88</b>		
mCCT (Durkan) <sup>26</sup>	28	52	64			30
PPT <sup>30</sup>	135		<b>54</b>	<b>68</b>		
Tinel <sup>33</sup>	60	41	<b>66</b>	<b>83</b>		
Tourniquet Gilliat <sup>33</sup>	60	41	<b>85</b>	<b>95</b>		
Tethered median stress <sup>35</sup>	58	44	<b>50</b>			<b>59,1</b>
Phalen + mCCT <sup>12</sup>	95	96	<b>86</b>	<b>95</b>		
Phalen + tourniquet <sup>13</sup>	33		80			17
Phalen + tourniquet <sup>38</sup>			<b>92</b>			<b>95</b>
Provocative test <sup>33</sup>	60	41	<b>98</b>	<b>98</b>		
ULTT <sup>26</sup>	28	52	75			13

**Table 3**

**Values of sensitivity and specificity, and evaluation of reliability of carpal tunnel syndrome provocative tests described by Massy – Westropp et al.<sup>23</sup>**

Test	Sensitivity [%]	Specificity [%]	Reliability assessment (maximum number of points - 17)
Phalen test + mCCT	82	99	10
Tinel test	75		10
Tinel test	63	55	10
Phalen test	43		10
Phalen test	47		9
Tinel test	45		9
Durkan test (mCCT)	87	90	8
Durkan test (mCCT)	49	54	8
Tinel test	60	40	8
Phalen test	58	54	8
Phalen test	86	48	7
Tinel test	62	57	7
Phalen test	83	67	6
Reverse Phalen test	55	100	6
Tinel test	58	67	6
Durkan test (mCCT)	89	96	5
Use of Ultrasound	92	88	2

**Table 4**

**Ranges of sensitivity and specificity values obtained by various authors**

Test	Sensitivity [%]	Specificity [%]	References
Phalen test	43-93	40-95	9,12,13,16,18,23-26,29,33
Reverse Phalen test	54-88	78-100	13,18,23,33
Durkan test	49-90	30-96	9,12,13,16,18,23,26,30,33
Tinel test	43-75	40-99	9,12-14,16,18,23,24,26,29,33
Tourniquet Gilliat	36-85	60-95	13,18,24,33
Tethered Median Stress Test	48-50	59-76	18,35
Phalen test + mCCT	80-82	90-99	12,18,23
Phalen test + tourniquet test	80-92	17-95	13,38

ing a larger group of patients<sup>18</sup> suggests that this test is not useful in CTS diagnosis, whereas results obtained in the other study are only slightly greater than 50%.

Tests of too low sensitivity and specificity include: lumbrical provocation, presence of the flick sign in the combined Phalen and tourniquet

test, median nerve compression test (upper limb compression test).

There are problems with determining the usefulness of the ultrasound test, as it reached very high sensitivity and specificity values, yet the method of evaluation of test usefulness fulfilled only 2 out of 17 criteria<sup>23</sup>.

The VPT and the hand elevation test were not classified.

Massy-Westrop et al.<sup>23</sup> presented an interesting classification of studies evaluating usefulness of provocative tests in the diagnosis of CTS (Table 3). In their published study, each test assessing sensitivity and specificity of diagnostic tests was evaluated with respect to the number of fulfilled criteria determining reliability of a given provocative manoeuvre. For each fulfilled criterion, 1 point was given. Maximum number of possible points was 17. Studies assessing the effectiveness of diagnostic tests were classified according to the number of points given for the fulfilled criteria – the more points gained, the greater objectivity of the obtained results.

Looking at the results presented in the tables 1, 2, 3, and 4, huge discrepancies in the values of test sensitivity and specificity reported by various authors can be noted. It seems that these discrepancies majorly depend on the following factors:

1. Methodology of a test (e.g. use of excessive force, very abrupt hit onto the carpal region or too long duration of provocation can induce paresthesiae even in a healthy nerve). For example, studies by Tetro et al.<sup>25</sup> demonstrate that sensitivity and specificity values depend on the duration of the combined Phalen and Durkan test:
  - if symptoms occur after 10 seconds: sensitivity – 67%, specificity – 99%,
  - if symptoms occur after 30 seconds: sensitivity – 86%, specificity – 95%.
2. Interpretation of particular tests results and assessment of subjective sensations experienced by patients during the tests (the fact that provocative tests rely on subjective data is the greatest drawback of provocative tests)
3. Characteristics of the evaluated group:
  - inclusion into studies a population without CTS but with similar symptoms reduces specificity – table 5<sup>16</sup>,
  - diversity and specific characteristics of patients treated by

- various specialists are different (neuro-logists, neurosurgeons, orthopaedists, rheumatologists)<sup>16</sup>,
  - sensitivity can reach a falsely positive value when a test is performed in patients with severe or very characteristic CTS<sup>30</sup>.
4. Lack of an ideal criterion allowing establishing the diagnosis of CTS in 100%. The following studies can serve as gold standards:
- electrodiagnostic study – however, in scholarly literature, it has been argued that that this study is not 100% reliable; e.g. Grunberg<sup>39</sup> reported 8% negative results of electrodiagnostic studies in a group of 32 hands considered to have CTS according to other criteria; similar data were reported by Tetro<sup>12</sup>; Atroshi<sup>40</sup> states that results of electrodiagnostic studies may be normal in 8 – 30% of persons with clinical symptoms and signs of CTS; Redmond and Rivner<sup>41</sup> report that they observed 46% falsely positive results among 50 electrodiagnostic studies in healthy, symptom-free persons;
  - the fact that symptoms are relieved after surgical decompression of the median nerve<sup>40</sup>; it seems, however, that even this criterion may turn out to be unreliable, as patients seeking confirmation of their inability to work (disability pension) may report incomplete alleviation of symptoms following surgery thus increasing the number of falsely negative results;

- Katz – Stirrat hand diagram – in a situation, where symptoms reported by the patient are classified as classical or probable CTS<sup>30</sup>; yet, also this method seems to fail sometimes, as many persons filling the scheme are not sure as to the localization of paresthesiae, numbness or pain; they frequently describe that the symptoms are present in the whole hand; patients with particularly intense night-time symptoms have problems with recalling, where precisely on the hand the symptoms were occurring<sup>20</sup>.
5. Sequence of performance of provocative tests evaluated in a given study. Tetro<sup>25</sup> thinks that it is possible that the effects of provocative manoeuvres may add to each other and sum up to produce an increased result of a test performed at the end.
- Szabo et al.<sup>16</sup> reported that specificity of provocative tests depends on the characteristics of the evaluated group. In the described study, patients were divided into three groups: 1 – patients with confirmed CTS (87 hands), 2 – patients with symptoms similar to CTS but not fully conforming to the clinical diagnosis of CTS (golfer's, tennis player elbow syndrome, radiculopathy or hand pain of unknown aetiology) (90 hands), 3 – healthy patients (100 hands) (see Table 5).

Based on the above study, it can be stated that differences in the values of specificity of provocative tests can be due to characteristic features of a population of studied persons. Specificity reached higher values in the

group of patients with classical CTS (group 1) and in healthy persons (group 3). Specificity was decreased, when the population was enlarged with the persons from the group 2 (pathology other than CTS). When the healthy group was excluded and only the groups with CTS and similar diseases were included in the analysis (thus simulating a typical group seeking surgeon's help), specificity was reduced but sensitivity remained constant<sup>16</sup>.

## DISCUSSION

Provocative tests are broadly required for confirmation of the diagnosis, treatment selection and determination of the causa and aetiology of CTS<sup>16,24</sup>. Despite the fact that electrodiagnostic studies are considered to be gold standard (abnormal test result is an objective prove of CTS<sup>40</sup>), however, a positive result cannot confirm the diagnosis of CTS when there are no symptoms<sup>12,16</sup>. Some patients with characteristic CTS signs may be qualified as candidates for surgical intervention and thus avoid costs and time associated with electrodiagnostic study<sup>29</sup>.

The fact that clinical tests are an available and easy-to-use diagnostic method constitutes their greatest advantage<sup>16</sup>. The majority of authors agree that a positive result of high sensitivity and specificity provocative tests is an indication for further studies verifying the diagnosis, while a negative result does not exclude CTS<sup>25</sup>.

Tests with high sensitivity should be used to differentiate patients with

**Table 5**

Values of sensitivity and specificity of provocative tests for various control groups according to Szabo et al. <sup>16</sup>						
	Group 1 + 3	Group 1 + 3	Group 1 + 2 + 3	Group 1 + 2 + 3	Group 1 + 2	Group 1 + 2
Test	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity
Phalen	75%	95	75%	71%	75%	62%
Tinel	64%	99	64%	83%	64%	71%
Durkan	89%	91	89%	66%	89%	45%

1 – patients with confirmed CTS (87 hands)  
 2 – patients with symptoms similar to those of CTS but not conforming to the clinical diagnosis of CTS (golfer's, tennis player elbow syndromes, radiculopathy, hand pain of unknown aetiology) (90 hands)  
 3 – healthy persons (100 hands)

symptoms similar to CTS, while tests with high specificity can serve to eliminate falsely positive results and are thus especially useful in cases, when surgical intervention is considered<sup>16,18</sup>.

To improve the effectiveness of provocative tests, certain standards pertaining to the method of their conduction and interpretation should be determined<sup>16</sup>.

Considering that CTS is especially frequent in persons performing manual jobs (typists, cashiers, car mechanics, musicians playing keyboard instruments, masseurs, confectioners, bakers, computer programmers, dentists etc., as well as persons working in conditions of lower temperature), provocative tests of high sensitivity may be applied to monitor harmful factors at work place<sup>3,4,6,8,9,16</sup>.

Given that CTS is due to mechanical irritation of the median nerve by the flexor retinaculum and that patients have positive results of tests increasing carpal tunnel pressure and compressing the median nerve, surgery alleviates CTS symptoms by reducing the pressure inside the carpal tunnel. Results reported by Boland and Adams suggest, however, that some cases can be elicited by other than mechanical factors, e.g. a vascular factor involved in production of CTS symptoms in 44% of patients<sup>11</sup>. Therefore, patients with a positive result of the VPT and a negative result of tests increasing carpal tunnel pressure and compressing the median nerve may be treated with agents reducing venous hyperaemia<sup>11</sup>.

If CTS is suspected in patients undergoing dialysis, the combined Phalen + tourniquet test is especially useful because of its high sensitivity and specificity (92 and 95%)<sup>38</sup>.

Provocative tests may serve as a tool to assess treatment results of both surgical and conventional therapy. Nawrot et al.<sup>13</sup> and Szyluk et al.<sup>9</sup> showed in their publication that after median nerve decompression, the incidence of positive Tinel, Phalen, reverse Phalen, Durkan, tourniquet and Phalen+tourniquet test results is decreased.

It should be kept in mind that the presented provocative tests are char-

acterised by high sensitivity and specificity in combination with other tests and diagnostic methods used to establish the diagnosis of CTS (e.g. tests evaluating superficial sensation)<sup>14,33</sup> and that it is worth conducting several provocative tests to increase correctness of diagnosis<sup>13</sup>. A tendency is currently observed to search for an optimal combination of various diagnostic elements to increase the efficacy of diagnosis (history, clinical signs, provocation tests)<sup>12,16,26</sup>. Szabo et al.<sup>16</sup> showed that use of the following combination: positive result of the Durkan test, abnormal superficial sensation threshold observed using Semmes-Weinstein monofilaments<sup>27</sup>, a result of Katz Stirrat Hand Diagram corresponding to classical or probable CTS and presence of nocturnal aggravation of symptoms constitutes a tool of high sensitivity and specificity. If the 4 elements are abnormal, correct diagnosis can be established in at least 86% of cases. Conversely, if all conditions and or tests were correct, the probability of CTS was as low as 0.68%<sup>16</sup>. Other researchers<sup>26</sup> indicate that combination of 5 elements: result obtained in the CTS Symptom Severity Scale – SSS >1.9, decreased sensation over the thumb, age greater than 45 years, ratio of the wrist A-P dimension to wrist width >0.67 and presence of the "flick" sign is an effective method.

## CONCLUSION

Provocative tests are essential to confirm the diagnosis even if the diagnosis of CTS was established by means of electrodiagnostic studies.

Tests characterised by high sensitivity and specificity: the provocative test, the Phalen test + mCCT, the Tinel test, the reverse Phalen and the mCCT are of especially high clinical importance.

To improve the effectiveness of provocative tests, uniform standards for their conduction and interpretation should be formulated.

Performance of several provocative tests increases the specificity of diagnosis (at the cost of sensitivity)

and is therefore indicated in situations, where surgical intervention is considered.

Positive result of provocative tests with high sensitivity and specificity with concomitant characteristic symptoms of the disease, confirmed with appropriate diagrams or questionnaires and presence of sensation abnormalities in the region innervated by the median nerve allows omitting the electrodiagnostic study to confirm the diagnosis of CTS.

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