

## Sonographic diagnosis of carpal tunnel syndrome – diagnostic value of the triangular cross-section sign

### *Ultrasonograficzne rozpoznanie zespołu kanału nadgarstka – wartość objawu trójkątnego przekroju poprzecznego nerwu pośrodkowego*

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#### Abstract

**Background and purpose:** Carpal tunnel syndrome (CTS) is a common neuropathy resulting from compression of the median nerve at the carpal tunnel. Sonographic diagnosis of this condition relies on enlargement, flattening and/or demonstration of impaired mobility of the median nerve, as well as bowing or thickening of the flexor retinaculum. In most patients the cross-section of the median nerve at the level of the carpal tunnel has an oval or elliptical shape. We have noticed, however, that in a number of cases the cross-section of the median nerve at the inlet of the carpal canal was deformed, assuming a triangular shape. The purpose of this study was to assess the diagnostic value of the triangular median nerve cross-section sign.

**Material and methods:** One hundred and thirty-nine sonographic examinations in 76 patients with clinical signs of CTS, and 25 examinations in 14 healthy volunteers were performed. Standard electrodiagnostic studies were performed in all symptomatic patients.

**Results:** Triangular shape of the median nerve cross-section in the carpal canal was observed in 13/118 (11.0%) median nerves with abnormal result of the electrodiagnostic study, and in 2/21 (9.5%) cases with a normal electrodiagnostic examination result. No such deformation was seen in the control group.

#### Streszczenie

**Wstęp i cel pracy:** Zespół kanału nadgarstka jest często występującą neuropatią związaną z uciśnięciem nerwu pośrodkowego w kanale nadgarstka. Ultrasonograficznymi cechami tej choroby są pogrubienie i spłaszczenie nerwu, ograniczenie jego ruchomości w badaniu dynamicznym, a także pogrubienie troczków zginaczy oraz ich dłoniowe uwypuklenie. U osób zdrowych i u większości pacjentów cierpiących na zespół kanału nadgarstka przekrój poprzeczny nerwu pośrodkowego na poziomie kanału nadgarstka ma kształt owalny lub eliptyczny. Podczas wykonywania badań ultrasonograficznych zaobserwowano jednak, że u części pacjentów cierpiących na tę chorobę nerw pośrodkowy jest zdeformowany w kanale nadgarstka, a jego przekrój poprzeczny przyjmuje kształt trójkątny, modelując się na ścięgnach zginaczy palców. Celem pracy była ocena wartości diagnostycznej objawu trójkątnego przekroju poprzecznego nerwu pośrodkowego.

**Materiał i metody:** Wykonano 139 badań u 76 pacjentów z klinicznymi objawami zespołu kanału nadgarstka oraz 25 badań u 14 zdrowych ochotników. U wszystkich pacjentów z klinicznymi objawami zespołu kanału nadgarstka wykonano badania elektrodiagnostyczne.

**Wyniki:** Trójkątny kształt przekroju poprzecznego uwidoczono w 13/118 (11,0%) badań u pacjentów z nieprawidłowym

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**Conclusions:** The triangular cross-section sign has high specificity (0.90) and positive predictive value (0.87) in diagnosis of CTS.

**Key words:** carpal tunnel syndrome, ultrasound, median nerve.

## Introduction

Carpal tunnel syndrome (CTS) is a common entrapment neuropathy resulting from compression of the median nerve at the carpal tunnel [1]. The diagnosis of CTS is based on a combination of characteristic clinical symptoms (pain, numbness and tingling in the distribution of the median nerve) [2], nerve conduction studies and diagnostic imaging (sonography or magnetic resonance imaging).

Sonography has been proven effective in the diagnosis of carpal tunnel syndrome, relying on enlargement [3,4] and/or flattening of the median nerve [5,6], palmar bowing of the flexor retinaculum [7], thickening of the flexor retinaculum [8], impaired mobility of the median nerve [9], and radial slide of the median nerve [10]. However, the morphological features (nerve swelling) do not necessarily reflect the clinical symptoms or functional status of the median nerve [11].

On transverse sonographic scans, the normal median nerve is elliptical and flattens as it runs distally [9]. How-

wynikiem badania elektrodiagnostycznego oraz w 2/21 (9,5%) przypadków z prawidłowym wynikiem badania elektrodiagnostycznego. Nie obserwowano takiej deformacji u żadnego ze zdrowych ochotników.

**Wnioski:** Objaw trójkątnego przekroju poprzecznego nerwu pośrodkowego cechuje się dużą swoistością (0,90) i wartością predykcyjną wyniku dodatniego (0,87) w ultrasonograficznym rozpoznaniu zespołu kanału nadgarstka.

**Słowa kluczowe:** zespół kanału nadgarstka, ultrasonografia, nerw pośrodkowy.

ever, performing sonographic examinations in patients with clinical suspicion of carpal tunnel syndrome, we have noticed different shapes of the cross-section of the median nerve in the carpal canal. In some cases the median nerve was strikingly deformed and seemed squeezed between the flexor retinaculum, assuming a triangular shape (Figs. 1-4).

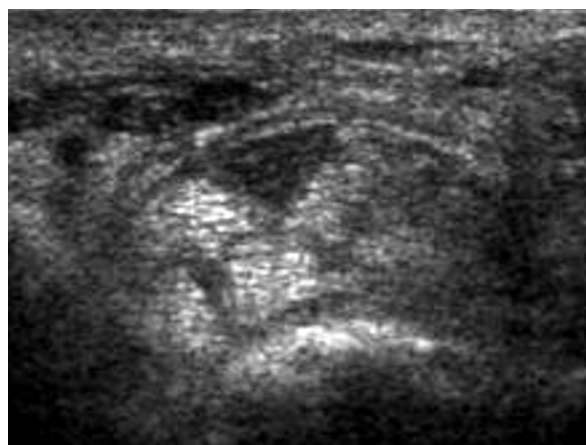
The purpose of this study was to determine the value of the triangular cross-section sign in diagnosis of carpal tunnel syndrome.

## Material and methods

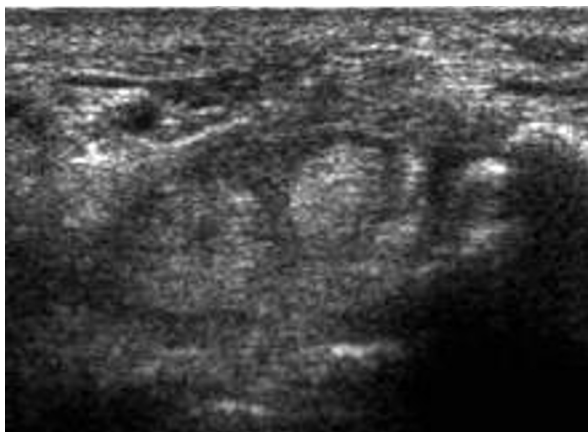
One hundred and thirty-nine sonographic examinations of the median nerve in 76 patients with clinical diagnosis of carpal tunnel syndrome (65 females and 11 males, mean age 53, age range 23-92) and 25 sonographic examinations in 14 asymptomatic, healthy controls (11 females, 3 males, mean age 46, age range 28-83) were performed with an HDI 5000 (Advanced Technology Laboratories, Bothell, Washington) scanner,



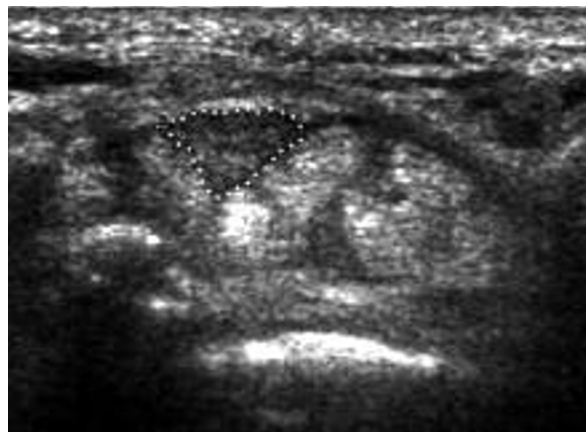
**Fig. 1.** Carpal tunnel syndrome in a 56-year-old woman. Transverse sonographic scan shows triangular deformation of the slightly enlarged (11 mm<sup>2</sup>) median nerve cross-section



**Fig. 2.** Carpal tunnel syndrome in a 79-year-old woman. Transverse 5-12 MHz sonographic scan shows triangular deformation of the enlarged (16 mm<sup>2</sup>) median nerve cross-section



**Fig. 3.** Carpal tunnel syndrome in a 79-year-old woman. Transverse 5-12 MHz sonographic scan shows triangular deformation of the enlarged (23 mm<sup>2</sup>) median nerve cross-section



**Fig. 4.** Carpal tunnel syndrome in a 46-year-old woman. Transverse 5-12 MHz sonographic scan shows triangular deformation of the enlarged (20 mm<sup>2</sup>) median nerve cross-section

using a linear 5-12 MHz probe. Sonographic examinations were performed by one examiner (K.S), who was not informed about the electrodiagnostic findings.

Patients were seated facing the physician performing the sonographic examination. The patients' arms were semi-flexed, wrists were rested on patients' thighs, forearms were supinated, and the fingers were semi-extended.

Transverse images of the median nerve were obtained at the carpal tunnel inlet – immediately distal to the proximal edge of the flexor retinaculum.

The cross-sectional area of the median nerve was measured by tracing of the margin of the nerve outside the hypoechoic nerve fascicles.

Electrodiagnostic studies were performed in all symptomatic patients. The studies were performed on a commercial basis by one experienced examiner (Dr. Katarzyna Osiak) in an external institution (Laboratory of Electromyography of the Witold Orłowski Hospital, Warsaw, Poland). Median motor nerve terminal latency, and median sensory nerve distal conduction velocity were determined using a 1-channel Medelec Sapphire electromyography unit. Latency > 0.68 ms/cm and velocity < 41.4 m/s were considered abnormal [12].

**Table 1.** Diagnostic accuracy of the triangular cross-section sign compared with electrodiagnostic examination

Sensitivity	0.11
Specificity	0.90
Positive predictive value	0.87
Negative predictive value	0.15

Patients with bifid median nerve were excluded from this study.

Statistical analysis was performed with the Statistica 7.1 (StatSoft) software. A non-parametric Wilcoxon test was used to evaluate the statistical difference of cross-sectional area in symptomatic patients with abnormal results of electrodiagnostic study (non-triangular and triangular shape of the cross-section), symptomatic patients with normal electrodiagnostic results, and the cross-sectional area of the median nerves in asymptomatic volunteers.

A *p* value of less than 0.05 was considered to indicate a statistically significant difference.

## Results

Triangular shape of the median nerve in the carpal canal was observed in 13/118 (11.0%) median nerves with an abnormal result of the electrodiagnostic study, and in 2/21 (9.5%) cases with a normal electrodiagnostic examination result. No such deformation was seen in the control group (Table 1).

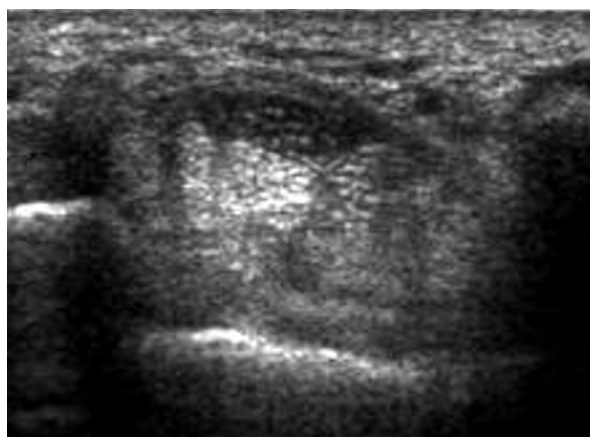
The mean cross-sectional area of the median nerve was significantly greater in symptomatic patients than in the control group.

In symptomatic patients with abnormal results of electrodiagnostic examination, the mean cross-sectional area of the 'triangular' median nerves was not significantly greater than the mean cross-sectional area of the 'non-triangular' median nerves.

In patients with clinical signs of CTS, the mean cross-sectional area did not significantly differ between patients with abnormal and normal results of electrodiagnostic examination.

**Table 2.** Sonographic measures of the cross-sectional area of the median nerve in symptomatic patients and the control group

Result of electrodiagnostic examination		n	Mean cross-sectional area (range) [mm <sup>2</sup> ]	Cross-section shape	n	Mean cross-sectional area (range) [mm <sup>2</sup> ]
Symptomatic patients	Abnormal	118	13.9 (6.0-30.0)	Non-triangular	105	13.6 (6.0-30.0)
				Triangular	13	16.2 (11.0-25.0)
	Normal	21	10.8 (6.0-17.0)	Non-triangular	19	11.0 (6.0-17.0)
				Triangular	2	9.0 (7.0-11.0)
Asymptomatic control group		25	9.2 (6.0-15.0)			



**Fig. 5.** Carpal tunnel syndrome in a 42-year-old woman. Transverse 5-12 MHz sonographic scan shows oval cross-section shape of the massively enlarged (24 mm<sup>2</sup>) median nerve

The mean cross-sectional area of the median nerve was significantly greater in patients with abnormal results of electrodiagnostic examination than in the control group.

However, the mean cross-sectional area of the median nerve did not significantly differ in symptomatic patients with normal results of electrodiagnostic examination and in the control group (Table 2).

## Discussion

Several authors have used flattening of the median nerve as a sign of carpal tunnel syndrome. However, the triangular shape of the cross-section of the median nerve in the carpal canal to our knowledge has not been reported yet. The nerve deformation is probably due to the increased dimensions of the thickened nerve and pressure inside the carpal tunnel. However, not all median nerves, even those with cross-sectional area as large as 24 mm<sup>2</sup>, are deformed (Fig. 5).

Therefore, we speculate that the striking deformation of the enlarged median nerve is due its softening, probably secondary to the inflammatory process. This assumption, however, needs to be corroborated by surgical, or elastographic data.

Although the sensitivity of the triangular cross-section sign is low, the specificity and positive predictive value of this sign are high. In nerves with cross-sectional area > 10 mm<sup>2</sup>, this sign has 100% specificity and positive predictive value in our material.

This study has several limitations. Due to time constraints the measurement of the cross-sectional area was performed only once. We used the EMG examination as the reference standard in this study. Our results confirm the high sensitivity of this method reported in the meta-analysis of Jablecki *et al.* [13]. However, it is well known that although there is a high degree of correlation between the conduction abnormalities and the measurement of the cross-sectional area of the median nerve [10,14], electrodiagnostic examinations may have a large false negative rate with sensitivities ranging from 49% to 86%. Consequently, a normal conduction velocity does not rule out the presence of compression [2,3,11].

We did not perform Power Doppler assessment of the nerves on a regular basis. It was done in the initial phase of the study, but, contrarily to the recently published data of Mallouhi *et al.* [15], in our opinion it did not yield additional information. Consequently, it was abandoned. Higher sensitivity of Power Doppler in the study of Mallouhi *et al.* may be due to the fact that they used a 7-15 MHz probe, while we used a 5-12 MHz probe.

## Conclusion

Triangular shape of the cross-section of the median nerve in the carpal canal is a highly specific sign of carpal canal syndrome.

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## Disclosure

Authors report no conflict of interest.

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