



SKIN SURFACE TEMPERATURE CHANGES BEFORE AND AFTER MEDIAN NERVE DECOMPRESSION IN CARPAL TUNNEL SYNDROME

Lucija Pavljak, Krešimir Bulić, Maksimilian Mrak and Anko Antabak

School of Medicine, University of Zagreb, Department of Surgery, Zagreb University Hospital Center, Zagreb, Croatia

SUMMARY – Carpal tunnel syndrome is the most common upper extremity compression neuropathy caused by compression of the median nerve at the wrist. Along with motor and sensory fibers, sympathetic fibers also pass through the median nerve, playing an important role in the regulation of blood flow to the skin which interacts between the body interior and its environment. The aim of this study was to examine the pre- and postoperative correlation between skin temperature changes in the area innervated by compressed median nerve compared to the skin areas innervated by radial and ulnar nerve and median nerve of the unaffected hand. The study included 16 patients with carpal tunnel syndrome with an indication for open carpal tunnel decompression. Skin temperature was measured preoperatively, at 2-week, 2- and 6-month follow-ups on the areas innervated by median, ulnar and radial nerve of the affected hand and median nerve of the non-affected hand. On the affected hand, median nerve innervated skin temperature showed maximum increase at 2-month follow-up before decreasing to a level higher than preoperatively. Radial nerve innervated skin temperature was lower than the preoperative value at 2-week follow-up, increasing to higher levels afterwards. Ulnar nerve temperature followed the curve of the median nerve innervated skin at all follow-ups. Unaffected median nerve innervated skin temperature increased at all follow-ups compared to the preoperative values. In conclusion, two or even five additional measurements should be made after at least one year. The results should be correlated with clinical and electromyoneurography recovery.

Keywords: *Median nerve; Carpal tunnel syndrome; Skin temperature; Sympathetic fibers*

Introduction

Carpal tunnel syndrome (CTS) is the most common upper extremity compression neuropathy with a prevalence estimated as high as 3.72%¹. Neuropathy develops due to compression of the median nerve at

the wrist as it runs through the fibro-osseous canal bounded by the concave bony arch of the carpus and the transverse carpal ligament (TCL)^{2,3}. Symptoms include intermittent pain and paresthesia or numbness (or both) in the median nerve distribution (thumb, index, middle finger, and radial side of the ring finger)^{2,4}. The history and physical examination are cornerstones for diagnosis³. Electrodiagnostic and imaging studies remain complementary methods⁵. When a regimen of conservative treatment, which includes night splinting and corticosteroid injection, fails to relieve the patient symptoms, surgical decompression of the median

Correspondence to: *Lucija Pavljak, MD*, Department of Surgery, Zagreb University Hospital Center, Kišpatičeva 12, HR-10000 Zagreb, Croatia
E-mail: lucija.pavljak@gmail.com

Received December 8, 2020, accepted May 20, 2022

nerve is recommended⁴. Release of the TCL may be performed using an open or endoscopic technique with open carpal tunnel release as the most common method of decompression⁵.

Skin is a dynamic membrane which interfaces between the body interior and its environment, playing an important role in the regulation of body temperature⁶. The temperature of skin surface varies according to the environmental temperature, temperature of the body, conditions in skin itself and its underlying structures⁷.

The median nerve in the hand encompasses motor, sensory and autonomic sympathetic fibers^{8,9}. One of the principal functions of the afferent sympathetic hand nervous system is associated with smooth muscle or blood vessel control with skin temperature continuously changing according to the blood circulation to the skin^{6,10}. Thus, the sympathetic nervous system is the most important factor for regulating blood flow to the skin¹⁰. Considering peripheral localization in the nerve, fine and unmyelinated composition, the sympathetic fibers are at a high risk of damage, especially in the very early phase of CTS^{9,11}. With sympathetic fibers being disrupted, changes in the vasomotor activity in the nerve innervation area can be expected, accompanied by changes in the skin temperature⁹.

Materials and Methods

The research was conducted at the Zagreb University Hospital Center, Zagreb, Croatia, between November 2014 and October 2015. The study included 16 consecutive CTS patients with an indication for open carpal tunnel decompression (Table 1). We excluded patients with bilateral disease, diagnosed either by the nerve conduction study or clinically, patients with recurrent disease, diabetic patients, patients with peripheral vascular diseases or peripheral neuropathies due to other causes. The research was approved by the University of Zagreb, School of Medicine Ethics Committee, and informed consent was signed by all patients. All procedures were in accordance with ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Table 1. Patient data

	Female	Male	Total
No. of patients	12	4	16
Minimal age (yrs)	40	53	40
Maximal age (yrs)	77	76	77
Average age (yrs)	56	65	58

Skin temperature on the affected hand was measured on the areas of the hand innervated by the median, ulnar and radial nerves, and on the area innervated by the median nerve on the non-affected hand. A laser thermometer FS-300, non-contact infrared Thermofinder thermometer (HuBDIC Co., Republic of Korea) was used on measurements. The thermometer used was calibrated to measure the range of human temperature from 35 up to 45 °C. Skin temperature was measured 3 times on each reference point. Distance between the thermometer and reference point was 2 cm. Measurements were taken prior to operation and at 2-week, 2-month and 6-month follow-ups. All the measurements were conducted in constant environment with room temperature set at 22-24 °C, air humidity at 40%-60%, and timing at 8 AM-12 AM. On the day of measurement, to adopt properly to the examination conditions, patients were left for 15 minutes with both hands in standard position in the examination room. Median temperatures in the areas innervated by the median, ulnar and radial nerves were used on analysis. The t-test for dependent samples was used to compare difference in the values measured before and after surgery. The level of significance was set at $p < 0.05$.

Results

Skin temperature of the median nerve innervated skin on the unaffected hand increased at all follow-ups compared to the preoperative values (Fig. 1). Temperature of the skin innervated by the median nerve on the affected hand slightly increased 2 weeks after surgery. It continued to rise and reached the maximum level at 2-month follow-up, being significantly higher in comparison to the first two measurements ($p < 0.001$ and $p < 0.01$). In the following months, temperature

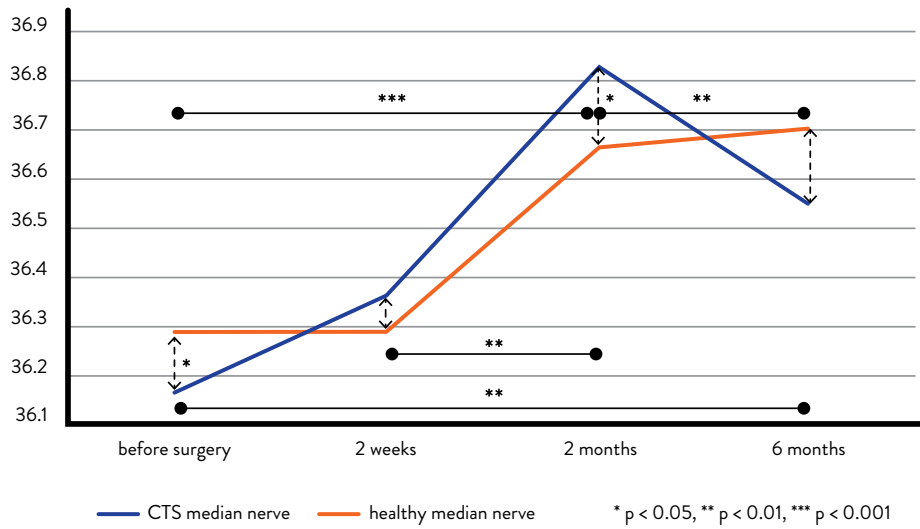


Fig. 1. Comparison of skin temperature between carpal tunnel syndrome and healthy median nerve.

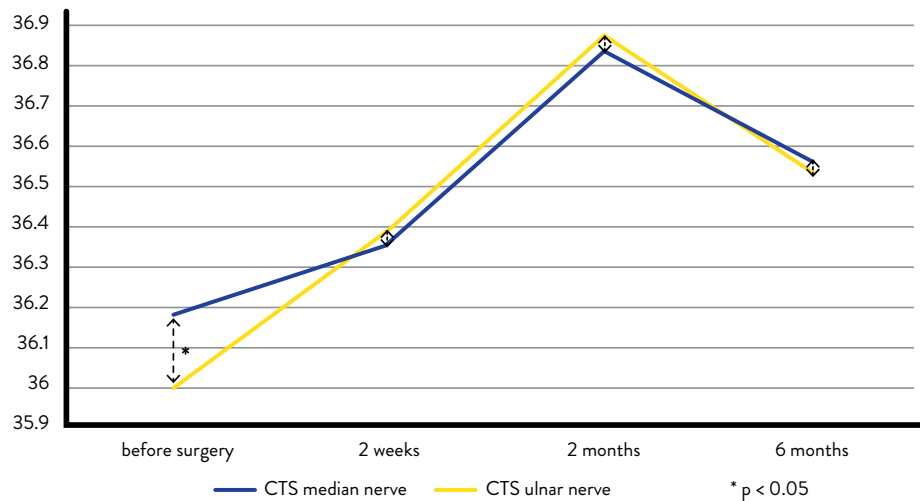


Fig. 2. Comparison of skin temperature between carpal tunnel syndrome median and ulnar nerve.

decreased to the level still significantly higher than before surgery ($p < 0.01$) (Fig. 1).

Preoperatively, the affected median nerve innervated skin temperature was significantly lower than the unaffected one ($p < 0.05$), followed by an increase of temperature 2 weeks and 2 months afterwards, when the affected hand had significantly warmer skin ($p < 0.05$). At last follow-up, as well as preoperatively,

healthy median nerve innervated skin temperature was significantly higher ($p < 0.05$) due to a significant decrease in the affected median nerve innervated skin temperature ($p < 0.01$) (Fig. 1).

In CTS hands, temperature of the ulnar nerve followed the curve of the median nerve innervated skin at 2-week, 2- and 6-month follow-ups, being significantly lower only preoperatively ($p < 0.05$) (Fig. 2).

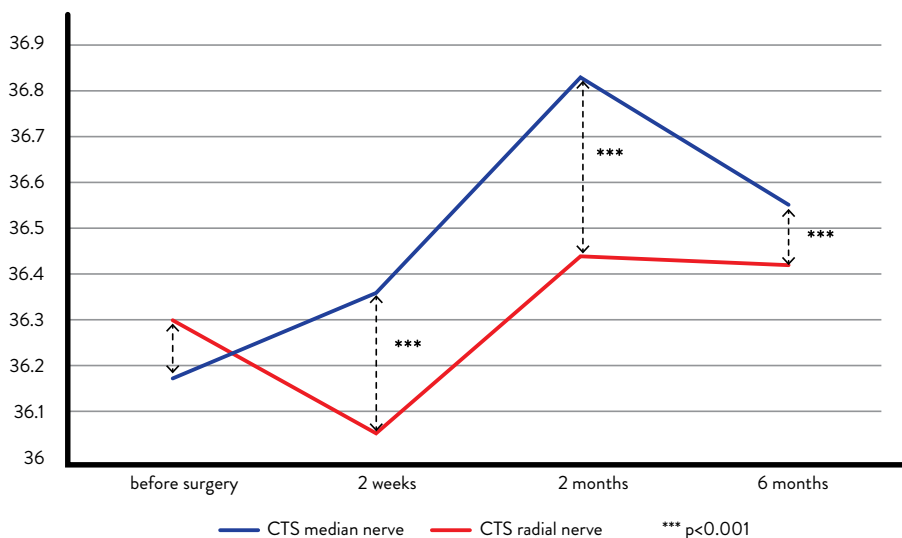


Fig. 3. Comparison of skin temperature between carpal tunnel syndrome median and radial nerve.

In CTS hands, temperature of the radial nerve innervated skin was lower than the preoperative value at 2-week follow-up, increasing to the levels higher than the preoperative value at the 2- and 6-month follow-ups. After preoperatively slightly higher temperature levels, radial skin innervated temperature was significantly lower than that in median nerve innervated skin ($p < 0.001$) (Fig. 3).

Discussion

Preoperatively, temperature of the affected hand was lower than that of the unaffected hand, probably because compression was going on for a long time and vasoconstriction occurred due to post denervation hypersensitivity of blood vessels to circulating catecholamines. If the pathologic condition had occurred more recently, paralytic denervation and temperature increase in the area of the damaged nerve would have occurred due to sympathetic denervation¹². Ming *et al.*¹³ also noticed such changes but due to lower temperature in the area of the ulnar nerve they could not conclude whether the area of the median was indeed changed. They offered centrally occurring changes in the regulation of pain, due to long-term pain, which

consequently led to vasoconstriction in the area of innervation of the adjacent nerve as a possible explanation for preoperative lower ulnar temperature values. In addition, it has been reported that along with CTS, Guyon canal syndrome evolves¹⁴. Due to the complexity of the anatomy of hand innervation, numerous anomalous connections have been described between these two nerves, such as Martin-Gruber, Cannieu-Riche and Berretini anastomoses, which can have a great clinical significance^{15,16}. Since both nerves contain sympathetic fibers¹¹, it is possible that a connection has been formed between them, so it is good to take this into account when unusual simultaneous deficits occur in the area of innervation of adjacent nerves.

At 2 weeks and 2 months after the operation, there was an increase in temperature on the affected hand, which could be explained by the inflammatory-reparative processes that raise temperatures in the affected area, as well as the appearance of temporary reactive postoperative hyperemia, which leads to increased flow and temperature¹⁷.

An increase in temperature was recorded on the unaffected hand, which could be explained by the research on unilateral compression of the radius nerve superficial ramus, which showed a bilateral stereotypical response. These bilateral changes lead to a conclusion

that there is a polysynaptic reflex trans-spinal transmission of neural impulses in both directions between the corresponding innervation zones¹⁸. In our study, there was decompression instead of compression, but the mechanism of occurrence probably was the same. In their review, Dec and Zyluk¹⁹ pointed out studies that reported improvement on non-CTS hands after decompression of median nerve on the other side, suggesting a much complex condition rather than individual entrapment neuropathy of both median nerves, with possible involvement of central mechanisms. The temperature of the ulnar area, lower preoperatively, rises, probably because of the proximity to the operated area, but also for other reasons. There are studies showing that decompression of the carpal tunnel leads to both a decrease in pressure and an increase in volume in the Guyon's canal and thus lead to the simultaneous release of not only one but both nerves²⁰. The changes in the radial nerve innervated skin, on the other hand, may be a reflection of the mechanism of lateral inhibition, which opposes the physiological tendency of intense stimuli to spread to the adjacent innervation region. It is activated in a phased manner with physiological fatigue and oscillations during the action of chronic stimulus¹⁸, which could also explain the oscillations in the temperature curve of the nerve.

After 6 months, temperature of the affected hand becomes lower again as compared to the unaffected one because the period of inflammatory hyperemia has already passed, and the neurological mechanisms have not yet recovered enough, thus stabilizing temperature in some way. In addition, it is possible that due to neurological mechanisms, treatment of the diseased nerve on one side induces development or worsening on the unaffected side²¹ through the mechanisms of paralytic vasodilation and post-dilation vasoconstriction¹², which requires additional measurements at longer intervals, which would be supported by bilateral nature of the syndrome itself²¹.

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Sažetak

PROMJENE TEMPERATURE KOŽE PRIJE I NAKON DEKOMPRESIJE MEDIJANOG ŽIVCA U SINDROMU KARPALNOG KANALA

L. Pavljak, K. Bulić, M. Mrak i A. Antabak

Sindrom karpalnog kanala predstavlja jednu od najčešćih kompresivnih neuropatija gornjeg ekstremiteta, do kojeg dolazi zbog kompresije medijanog živca na razini ručnog zgloba. Medijani živac se uz motorna i senzorna vlakna sastoji i od simpatičkih vlakana koja imaju važnu ulogu u regulaciji protoka krvi u kožu koja predstavlja poveznicu između vanjskog svijeta i ljudskog tijela. Cilj ovog istraživanja bio je ispitati prijeoperacijsku i poslijeoperacijsku povezanost između promjena temperature kože u području koje inervira komprimirani medijani živac u usporedbi s područjem kože koje inerviraju radijalni i ulnarni živac iste ruke i medijanog živca druge ruke. U studiju je bilo uključeno 16 bolesnika s dijagnozom sindroma karpalnog kanala kod kojih je postavljena indikacija za kirurški zahvat otvorene dekompresije živca. Temperatura kože u području inervacije komprimiranog medijanog živca, radijalnog i ulnarnog živca iste ruke i medijanog živca druge ruke mjerena je prijeoperacijski te u razdoblju od 2 tjedna, 2 i 6 mjeseci nakon operativnog zahvata. Na bolesnoj ruci temperatura kože u području inervacije komprimiranog medijanog živca bila je maksimalna 2 mjeseca nakon dekompresije, nakon čega je pala na i dalje veću vrijednost od prijeoperacijske. Temperatura kože u području inervacije radijalnog živca bila je niža 2 tjedna nakon operacije u odnosu na prijeoperacijsko razdoblje, uz daljnji kontinuiran rast. Temperatura kože u području inervacije ulnarnog živca pratila je cijelo poslijeoperacijsko razdoblje temperaturnu krivulju komprimiranog medijanog živca. Temperatura kože medijanog živca kontralateralne strane pokazala je kontinuirani rast temperature krivulje poslijeoperacijski u odnosu na prijeoperacijska mjerenja. U zaključku, potrebna su barem još dva do pet dodatnih mjerenja kroz razdoblje od godine dana nakon operativnog zahvata. Rezultate treba korelirati s kliničkim nalazom te nalazom elektromioneurografije.

Ključne riječi: Medijani živac; Sindrom karpalnog kanala; Temperatura kože; Simpatička vlakna