ORIGINAL PAPERS

Adv Clin Exp Med 2007, **16**, 1, 57–63
ISSN 1230-025X

ROMAN WIĄCEK[1], STANISŁAW PIELKA[1], ROMAN RUTOWSKI[1, 3], JERZY GOSK[1],
KRZYSZTOF SKIBA[1], PAWEŁ REICHERT[1]

Evaluation of the Dynamics of Hand Strength Improvement Following Surgical Treatment of Carpal Tunnel Syndrome

Ocena dynamiki poprawy siły ręki po operacyjnym leczeniu zespołu kanału nadgarstka

[1] Department and Clinic of Traumatology and Hand Surgery, Silesian Piasts University of Medicine in Wrocław, Poland
[2] Department of Experimental Surgery and Biomaterials Research, Silesian Piasts University of Medicine in Wrocław, Poland
[3] Chair and Department of Medicine of Sport in Wrocław University of Physical Education, Poland

Abstract

Introduction. The increasing incidence of carpal tunnel syndrome (CTS) is an escalating socioeconomic problem. Studies evaluating the results of its surgical treatment and analyses leading to defining prognosis thus have increasingly great significance.
Objectives. The purpose of the study was to evaluate the dynamics of hand strength changes after surgical treatment of carpal tunnel syndrome and to define prognosis concerning improvement of that strength.
Material and Methods. This study included 87 patients operated on with the classical method for carpal tunnel syndrome in The Department of Traumatology and Hand Surgery of Wrocław Medical University. The mean age of patients was 51.8 years. The evaluation included grip strength, key pinch, tripod pinch, and opposed pinch of the operated hand. The measurements were performed before surgery and one, three, and six months later.
Results. Decreases in strength were observed in each of the studied grip/pinch strengths in the control test one month after surgery. The largest difference in relation to the initial value was observed in opposed pinch strength. The largest increase in strength in the range of each grip/pinch test was observed between the first and third month after surgery. A further increase in strength was observed after the third month after surgery. This was statistically significant only in the case of grip strength. At six months, a 27% grip strength increase, 26% key pinch strength increase, 37% tripod pinch strength increase, and 35% opposed pinch strength increase were noted. Statistically significant increases in hand strength were not observed until six months after surgery.
Conclusions. In patients operated on because of carpal tunnel syndrome, a temporary decrease in hand strength appears directly after surgery. An increase in this strength is observed starting from the third month after surgery. Essential improvement of hand strength in patients with carpal tunnel syndrome is generally observed no sooner than six months after surgery (**Adv Clin Exp Med 2007, 16, 1, 57–63**).

Key words: carpal tunnel syndrome, surgical treatment, strength, grip, pinch.

Streszczenie

Wprowadzenie. Z powodu narastającego problemu socjoekonomicznego, jakim jest zwiększająca się zachorowalność na zespół kanału nadgarstka (z.k.n.), coraz większego znaczenia nabierają badania oceniające wyniki jego operacyjnego leczenia oraz analizy przyczyniające się do określenia rokowania.
Cel pracy. Ocena dynamiki zmian siły ręki po operacyjnym leczeniu zespołu kanału nadgarstka oraz określenie rokowania dotyczącego poprawy tej siły.
Materiał i metody. Badaniem objęto 87 chorych operowanych metodą klasyczną z powodu zespołu kanału nadgarstka w Klinice Chirurgii Urazowej i Chirurgii Ręki AM we Wrocławiu. Średnia wieku chorych wynosiła 51,8 lat. Ocenie poddano siłę chwytu globalnego, kluczowego, trójpalcowego i przeciwstawnego ręki operowanej. Pomiarów dokonano przed operacją, a następnie jeden, trzy i sześć miesięcy po zabiegu.

Wyniki. W przypadku każdego badanego chwytu w badaniu kontrolnym po upływie jednego miesiąca od operacji odnotowano obniżenie jego siły. Największą różnicę w stosunku do wartości wyjściowej zarejestrowano w przypadku siły chwytu przeciwstawnego. Największy przyrost siły w zakresie każdego badanego chwytu odnotowano między pierwszym i trzecim miesiącem od operacji. Powyżej trzeciego miesiąca od zabiegu odnotowywano dalszy przyrost siły, ale istotny statystycznie był on jedynie w przypadku chwytu globalnego. W czasie sześciomiesięcznego okresu obserwacji zarejestrowano 27% przyrost siły chwytu globalnego, 26% przyrost siły chwytu kluczowego, 37% przyrost siły chwytu trójpalcowego oraz 35% przyrost siły chwytu przeciwstawnego. W badanym materiale istotny statystycznie przyrost siły ręki po operacyjnym leczeniu zespołu kanału nadgarstka odnotowano dopiero po upływie 6 miesięcy od zabiegu.
Wnioski. U chorych operowanych z powodu zespołu kanału nadgarstka bezpośrednio po operacji występuje przejściowe obniżenie siły ręki. Przyrost tej siły obserwuje się od trzeciego miesiąca po operacji. Istotną poprawę siły ręki u chorych z zespołem kanału nadgarstka obserwuje się najczęściej dopiero po upływie 6 miesięcy od operacji (**Adv Clin Exp Med 2007, 16, 1, 57–63**).

Słowa kluczowe: zespół kanału nadgarstka, leczenie chirurgiczne, siła, chwyt.

Carpal tunnel syndrome (CTS) is the most often diagnosed entrapment neuropathy of the upper extremity. In 1865, Sir James Paget described for the first time the clinical symptoms of compression of the median nerve in the carpal tunnel as a result of fracture of the distal epiphysis of the radius [1, 2]. In 1938, Moersch introduced the name "carpal tunnel syndrome" into medical literature [3]. Tightness symptoms are caused by a disproportion between carpal tunnel volume and the structures constituting its content. The clinical picture of carpal tunnel syndrome is generally not full symptomatic. Subjective and objective symptoms may appear in particular patients in different combinations and be of variable intensity. A defect in hand muscle innervation is the cause of problems reported by patients in manipulating small objects. Conservative therapeutic methods for CTS most often produce fragmentary and short-lasting improvement, which is why most clinicians are of the opinion that a surgical procedure should be treated as the method of choice [4, 5].

An increasing tendency of cases of CTS has been observed in recent years. Moreover, taking into account the fact that the disease mainly affects people of productive age, it is becoming a serious socioeconomic problem. Because of theses considerations, evaluation of the results of surgical treatment of carpal tunnel syndrome is still a subject of numerous scientific studies. Lately, reports on CTS have particularly often presented the problem of long-lasting work disability of these patients and the costs of the applied treatment have been analyzed as well [6–8]. Clinical observations show that the percentage of patients satisfied with the applied treatment is now about 75–80% [5, 9, 10]. This is because of, among others things, partial recurrence of complaints in a certain percentage of patients. In others, the symptoms of dysfunction of the median nerve pass gradually in the course of a few weeks or months after surgery.

From the scientific and practical point of view, it would be valuable to define precisely the dynamics of changes in strength, sensitivity, and subjective improvement after surgical treatment of CTS. This would allow defining prognosis more precisely. Although single analyses available in the literature have dealt with this subject, controls were performed at large intervals and the numerical force of the studied groups often did not allowed obtaining statistically credible results. Only an analysis of strength improvement in the range of the operated hand will be presented here. The change in the dynamics of other parameters will be the subject of other publications.

The purpose of this study was to evaluate the dynamics of hand strength after surgical treatment of carpal tunnel syndrome and to define prognosis concerning improvements in hand strength after surgical treatment of CTS.

Material and Methods

This study included 87 patients operated on at The Department of Traumatology and Hand Surgery of Silesian Piasts University of Medicine in Wrocław, Poland from July 2002 to August 2004 because of carpal tunnel syndrome diagnosed clinically and confirmed by electroneurographic examination. This study included patients who were previously informed in detail about the method and purpose of the performed tests and who signed their consent. Seventy-eight females and 9 males were in the tested group. The mean age of patients was 51.8 years. Patients aged from 41 to 60 years constituted the most numerous group (74.7%). In 48 patients the disease appeared bilaterally, in 37 it involved only the dominant hand, and in two patients carpal tunnel syndrome appeared only in the non-dominant hand. All of the patients were operated for the first time. The average length of time of disease was 49 months, which is why most of the cases were treated at an

Table 1. Stages of CTS in the evaluated group according to Mondelli scale [11]

Tabela 1. Stopień nasilenia z.k.n. w badanej grupie chorych wg skali Mondelli [11]

Stage of CTS (Stopień nasilenia z.k.n.)	I	II	III	IV	V
Number of patients (Liczba pacjentów)	4	7	18	52	6

advanced stage of disease (Tab. 1). In 2/3 of the patients, different degrees of muscular atrophy of the thenar were noted.

The open method of surgery of carpal tunnel syndrome was applied in all patients. The procedure was performed in a bloodless field, with incision according to Kirk-Watson or Tanzer and anesthesia with 1.5% solution of lignocaine from the axillary approach.

The evaluation included grip strength, key pinch, tripod pinch, and opposed pinch of the operated hand. Measurements of grip strength were performed with a BASELINE® Hydraulic Hand Dynamometer of the company Smith & Nephew Rolyan Inc. A PG-30 (S/N B3I306) dynamometer of B&L Engineering was used to define key pinch, tripod pinch, and opposed pinch strength. The largest value achieved in a test of three trials was noted. The measurements were performed before surgery and one, three, and six months after the procedure. Absolute values of strength of the tested grips/pinches were taken into account in later calculations.

The obtained data underwent the Friedman ANOVA test to define differences between the results observed in the successive control tests. As the data had a normal distribution, they underwent analysis with Student's *t* test to check the zero hypothesis about the difference in mean values in successive control tests for each of the possible pairs of the given parameters. A p value lower than 0.05 was accepted as signifying a significant relationship between two tested parameters.

Results

The mean values of grip strength, key pinch, tripod pinch, and opposed pinch together with standard deviations observed in the four control tests are presented in Table 2. The high value of χ^2 in the Friedman ANOVA test and $p < 0.000001$ are evidence of very clear differentiation between the strength values observed in each control test. The preoperative mean value was accepted as 100% and the strength values observed in each subsequent control test are presented as percentages of the initial value for purposes of comparison.

Decreases are observed in each of the grip/pinch strengths in the control test one month after surgery. The greatest difference in relation to its initial value was observed in case of opposed pinch, with a 24% decrease. However, the strength decrease of that pinch was not characterized by high statistical significance as in the case of grip strength. Tripod pinch decreased the least, only by 6% in relation to the preoperative value. The largest increase in strength in each studied grip/pinch was observed between the first and third month after surgery. This was confirmed by the high statistical significance in Student's *t* test. The strength values of grip, key pinch, tripod pinch, and opposed pinch observed three months after surgery were higher than the initial values. In the case of tripod pinch the strength increase was already statistically significant. Further strength increases were observed after the third month after surgery, but they were statistically significant only in the case of grip. During the six-month observation period, a 27% increase in grip strength, 26% increase in key pinch strength, 37% increase in tripod pinch strength, and 35% increase in opposed pinch strength were observed. It should be noted that increases in tripod and opposed pinch strength were about 10% greater than the others. The strength of these pinches depends on correct innervation of the internal muscle of the hand by the median nerve.

Summing up, in the studied material, statistically significant strength increases of the hand after surgical treatment of carpal tunnel syndrome were generally not observed until six months after the procedure.

Discussion

Weakness in hand strength, in addition to pain and sensitivity disturbances, is one of the most important reasons for patients with carpal tunnel syndrome to come for surgical treatment. Unfortunately, the appearance of this symptom is evidence for a higher degree of disease progression and may be followed by worse treatment results. Weakness in an affected hand is particularly important for a patient who is a physical worker or

Table 2. Mean values of strength of the particular grips/pinches in the preoperative and subsequent controls

Tabela 2. Średnie wartości siły poszczególnych chwytów w badaniu przedoperacyjnym oraz w kolejnych badaniach kontrolnych

Kind of grip/pinch (Rodzaj chwytu)	Mean strength of grip/pinch (kg), % of preoperative value (Średnia siła chwytu (kg), % wartości wyjściowej)			
	preoperative control (badanie przedoperacyjne)	after 1 month (po upływie 1 miesiąca)	after 3 months (po upływie 3 miesięcy)	after 6 months (po upływie 6 miesięcy)
Grip (Globalny)	16.88 ± 8.45	13.58 ± 6.11	18.58 ± 6.43	21.42 ± 8.59
	100%	80.48%	110.05%	126.92%
Key pinch (Kluczowy)	5.37 ± 2.92	4.79 ± 2.19	6.09 ± 2.45	6.77 ± 2.98
	100%	89.12%	113.36%	126.00%
Tripod pinch (Trójpalcowy)	3.73 ± 1.79	3.49 ± 1.64	4.69 ± 1.88	5.10 ± 2.25
	100%	93.70%	125.85%	136.75%
Opposed pinch (Przeciw-stawny)	1.15 ± 0.96	0.88 ± 0.58	1.38 ± 0.95	1.56 ± 1.07
	100%	76.10%	119.33%	135.09%

◄—► statistically significant difference.

◄—► różnica istotna statystycznie.

has a job requiring precise hand movements. According to Shiota [12], particularly in the first case it is helpful to perform plasty of the flexors retinaculum, which results in a smaller postoperative decrease and faster return of strength after the first month after the procedure. Strength evaluation of grip, generally reflecting the functional state of the hand, is the most popular among researchers dealing with carpal tunnel syndrome [8, 9, 12–16]. This is in spite of the fact that grip strength, in comparison with the others, is the least dependent on changes observed in the median nerve at the wrist level. Performance of grip is also connected with irritation of the postoperative scar and weakness of grip strength in the reflex way.

Table 3 presents the strength values of the studied grips/pinches observed by other authors during the first six months after CTS surgical treatment, converted to percentages. The initial result was treated as 100% and the values obtained in successive controls as percentages of the initial value. Results presented in this way enable a better comparison of the studied groups of patients because they exclude the influence of the patients' individual skill, sex, age, and the side on which CTS appears (dominant or non-dominant hand). These factors significantly influence the strength values observed in particular patients, causing a large divergence in a seemingly homogenous group of patients. But it should be noted that when using this comparative method, the achievement of a relatively high percentage value of strength in a given control may not reflect the patients' higher satisfaction with the applied treatment and it does not indicate the ability to perform a specific job.

All the authors included in the comparative analysis observed a drop in grip strength in the first postoperative study. Although Gellman [15] did not use statistical tests defining the significance of this drop, from the percentage value of strength observed one month after surgery it should be expected that a statistically significant decrease in grip strength values was also reported in his material. In the material of Katz [16], the grip and the key pinch strengths six months after surgery were still largely weakened in relation to the preoperative state. These results, although rare, seem to confirm the opinion that section of the flexor retinaculum is not indifferent to the correct function of the motor apparatus of the hand. This is why some authors recommend performing plasty of the flexor retinaculum to prevent palmar subluxation of the finger flexor tendons after retinaculum section [12,17]. In the material analyzed in the present study, grip strength in the last control was 27% higher than the mean preoperative value, which is the best result reported in the available

Table 3. Percentage values of strength of the studied grip/pinches observed in successive control tests. Data from literature [8, 13–16]

Tabela 3. Wartości procentowe siły poszczególnych chwytów w kolejnych badaniach kontrolnych. Zestawienie danych z piśmiennictwa [8, 13–16]

Author (Autor)	Kind of grip/pinch (Rodzaj chwytu)															
	grip (globalny)				key pinch (kluczowy)				tripod pinch (trójpalcowy)				opposed pinch (przeciwstawny)			
	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
Agee et al. OCTR[A] N = 65	100	62	98	109	100	81	110	114	100	89	117	117	–	–	–	–
ECTR[B] N = 82	100	79	105	114	100	98	114	121	100	96	109	114	–	–	–	–
Katz et al. N = 35	100	50	54	67	100	72	104	85	–	–	–	–	–	–	–	–
Gellman et al.[C] N = 21	100	28	99	116	100	74	108	126	–	–	–	–	–	–	–	–
MacDermid et al. N = 32	100	86	123	–	100	97	92	–	100	123	138	–	–	–	–	–
Bednarski N = 39	100	–	109	123	100	–	105	117	100	–	114	130	–	–	–	–
Wiącek et al. (own studies) N = 87	100	80	110	127	100	89	113	126	100	94	126	137	100	76	119	135

I, II, III, IV – preoperative control and 1, 3, and 6 months post operation, respectively.
[A] – surgery with open method.
[B] – surgery with endoscopic method.
[C] – lack of data on the significance of changes of grip/pinch strengths in the particular study.

I, II, III, IV – badanie przedoperacyjne, po upływie jednego, trzech i sześciu miesięcy po operacji.
[A] – operacja metodą otwartą.
[B] – operacja metodą endoskopową.
[C] – brak danych o istotności statystycznej zmian siły chwytów w poszczególnych badaniach.

literature. It is worth noting that the studies which reported improvement in grip strength of more than 20% included patients treated with the classical method or, more rarely, with the "double incision open technique" (DIOT). This observation negates the conviction of adherents of endoscopic methods that the large scar in the wrist after surgery with the open method is the main cause of weakness in grip strength. Although the values of grip strength observed by Agee [13] one and three months after surgery were comparable with the ones reported in the material of the present study, he observed only a 14% increase in grip strength after six months (Tab. 3). In particular reports, weakness of key pinch strength one month after surgery varied from 2% to 28% of the initial value. In the case of the use of the endoscopic technique, the authors recorded a 2–3 percent drop in the studied grip/pinch strengths. Only in the results of endoscope treatment presented by Agee [13] and collaborators was a statistically significant improvement in key pinch strength recorded three months after surgery. In the percentage scale it was only higher by 1% than that reported in the present study. The values for key pinch strength reported in the present study are comparable to the results presented by other authors. But the decrease in key pinch strength in the period from the third to the sixth month after surgery in the material of Katz [16] is not understandable.

Observations by other authors confirm the fact that in the direct postoperative period, tripod pinch strength decreases to the smallest degree. In the material of MacDermid and collaborators [8], one month after surgery such decrease was not only not observed, but an increase in that pinch strength by 23% in relation to the initial value was reported. Therefore we can state that it is the pinch on

which the operative injury has the smallest influence. Perhaps that is why in the evaluation of that pinch strength, the final result of surgery was best in all authors.

In the available literature no data could be found dealing with measurements of opposed pinch strength, so it is not possible to perform a comparative analysis. Correct performance of that pinch depends on the innervation of the opponens of the thumb by the median nerve, which is why the measurement of its strength may be a good indicator of the degree of the intensity of changes in the that nerve. In addition, the observations of the present authors have shown that the strength of that pinch to a large extent depends on complaints connected with the postoperative scar. The 24% decrease in its strength in the control performed one month after surgery is evidence of this. From the observations of MacDermid [8] it appears that the effects of surgical treatment of CTS with the open and endoscopic methods are similar, particularly when it concerns the time after the third month after surgery. It is worth stressing that the postoperative increase in hand strength in the opinion of some authors is connected not only with the procedure itself, but also depends to a very large extent on the rehabilitation treatment applied to the patient during that period and the patient's motivation, for example, to return to a previously performed job [16,18]. That is why a very individual course of hand strength increase in particular patients is observed, which is confirmed by numerous publications.

Conclusions

In patients operated on because of carpal tunnel syndrome, a temporary decrease in hand strength appears directly after surgery. An increase in that strength is observed starting from the third month after surgery. Statistically significant improvement in hand strength in patients with carpal tunnel syndrome is most often observed no sooner than six months after surgery.

References

[1] Amadio PC: The first carpal tunnel release? J Hand Surg 1995, 20B, 40–41.

[2] Gelberman RH: Operative Nerve Repair and Reconstruction. J. B. Lippincott Company, Philadelphia 1996, 847–979.

[3] Michelson H, Posner MA: Medical history of carpal tunnel syndrome. Hand Clin 2002, 18, 257–268.

[4] Manikowski W, Walusiak D, Kiciński A: Wyniki leczenia operacyjnego zespołu kanału nadgarstka. Pol Hand Surg 1988, 2/12, 19–22.

[5] Skowrońska A, Palczewki D, Kubicki J, Palczewski P: Wyniki leczenia operacyjnego zespołu kanału nadgarstka w materiale własnym. Pol. Hand Surg 2000, (1), 35–39.

[6] Brhel P, Dufecut J, Rihova A, Bartnicka M: Rozwój zespołu cieśni nadgarstka (ZCN) po stwierdzeniu choroby zawodowej. Med Pr 2003, 54 (1), 17–21.

[7] Katz JN, Lew RA, Bessette L: Prevalence and predictors of long-term work disability due to carpal tunnel syndrome. Am J Ind Med 1998, 33, 543–550.

[8] MacDermid JC, Richards RS, Roth JH, Ross DC, King GJW: Endoscopic versus open carpal tunnel release: a randomized trial. J Hand Surg 2003, 28A, 475–480.

[9] Brüske J, Niedźwiedź Z, Bednarski M, Żyluk A: Ostry zespół kanału nadgarstka po złamaniach nasady dalszej kości promieniowej – ocena odległych wyników leczenia jednoczasową dekompresją i stabilizacją zewnetrzną. Chir Narządów Ruchu Ortop Pol 2002, 67 (1), 47–53.

[10] Kuś H, Rutowski R, Szczucki R: Pourazowe neuropatie uciskowe i regeneracja przerwanych nerwów w obrębie nadgarstka. Chir Narz Ruchu Ortop Pol 1997, Suplement 1, 91–94.

[11] Mondelli M, Passera S, Giannini F: Provocative test in different stages of carpal tunnel syndrome. Clin Neurol Neurosurg 2001, 103, 178–183.

[12] Shiota E, Tsuchiya K, Yamaoka K, Kawano O: Open surgical therapy for carpal tunnel decompression in long-term haemodialysis patients. J Hand Surg 2001, 26B, 6, 529–532.

[13] Agee JM, McCarroll HR Jr, Tortosa RD, Berry D.A, Szabo R.M, Peimer CA: Endoscopic release of the carpal tunnel: a randomized prospective multicenter study. J Hand Surg 1992, 17A, 987–995.

[14] Bednarski M, Żyluk A, Żyluk B: Ocena ewolucji siły chwytów po dekompresji kanału nadgarstka. Chir Narządów Ruchu Ortop Pol 2005, 70 (1), 21–26.

[15] Gellman H, Kan D, Gee V, Kuschner SH, Botte MJ: Analysis of pinch and grip strength after carpal tunnel release. J Hand Surg 1989, 14A, 863–864.

[16] Katz JN, Fossel KK, Simmons BP, Swartz RA, Fossel AH, Koris MJ: Symptoms, functional status, and neuromuscular impairment following carpal tunnel release. J Hand Surg 1995, 20A, 549–555.

[17] Mathur K, Pynsent BP, Vohra SB, Thomas B, Deshmukh SC: Effect of wrist position on power grip and key pinch strength following carpal tunnel decompression. J Hand Surg 2004, 29B, 4, 390–392.

[18] Kiwerska-Jagodzińska K, Mikuła W, Iwanowski M: Postępowanie usprawniające po leczeniu operacyjnym zespół kanału nadgarstka. Post Rehab 2001, 15 (1), 17–21.

Address for correspondence:

Roman Wiącek
Department and Clinic of Traumatology and Hand Surgery,
Silesian Piasts University of Medicine in Wrocław
ul. Traugutta 57/59
50-417 Wrocław
Poland
Tel.: +48 71 7332706
Fax: +48 71 7332709
e-mail: chiruraz@churaz.am.wroc.pl

Conflict of interest: None declared

Received: 8.12.2006
Revised: 5.01.2007
Accepted: 12.01.2007

Praca wpłynęła do Redakcji: 8.12.2006 r.
Po recenzji: 5.01.2007 r.
Zaakceptowano do druku: 12.01.2007 r.