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ORIGINAL ARTICLE

The Prognosis of Carpal Tunnel Syndrome Surgery in Patients with Hepatitis C Virus: A Prospective Comparative Study

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ABSTRACT

Background: Hepatitis C virus (HCV) infection is associated with various extrahepatic manifestations, including neurological complications. However, its impact on the outcome of carpal tunnel release surgery remains poorly understood. This study aimed to investigate whether HCV infection affects the prognosis of carpal tunnel surgery.

Methods: This prospective comparative study enrolled 24 patients with carpal tunnel syndrome divided into two groups: 12 patients with untreated HCV infection and 12 patients without HCV infection. All patients underwent open carpal tunnel release surgery with follow-up evaluations at 2 weeks, 3 months, and 6 months post-surgery. Outcomes assessed included relief of tingling, pain severity (Visual Analogue Scale), nerve conduction studies, and wound healing.

Results: Both groups had comparable demographic characteristics and preoperative clinical findings. Post-operatively, significant differences emerged: persistent tingling at 6 months was observed in 75% of HCV patients versus 8.3% of non-HCV patients ($p<0.001$). Pain severity remained significantly higher in the HCV group throughout follow-up, with 50% reporting moderate to severe pain at 6 months compared to complete resolution in the non-HCV group ($p<0.001$). Delayed wound healing occurred in 75% of HCV patients versus 16.7% of non-HCV patients ($p=0.004$). Nerve conduction studies showed better improvement in the non-HCV group.

Conclusions: HCV infection significantly impacts the prognosis of carpal tunnel surgery, being associated with persistent symptoms, delayed wound healing, and poorer nerve recovery. These findings suggest that HCV status should be considered when planning carpal tunnel release.

Keywords: Hepatitis C virus; carpal tunnel syndrome; surgical outcome; peripheral neuropathy; wound healing.

INTRODUCTION

About 3-6% of persons in the general population suffer with carpal tunnel syndrome (CTS), the most prevalent entrapment neuropathy [1]. The symptoms include pain, numbness, and tingling in the median nerve's distribution and, in more severe cases, weakness and atrophy of the thenar muscles. It is caused by compression of the median nerve as it travels through the carpal tunnel at the wrist. The most effective treatment for moderate to severe CTS is surgical relaxation of the transverse carpal ligament, with success rates ranging from 75% to 90% [1].

However, a number of circumstances can affect the results of surgery. Age, gender, length of symptoms, electrophysiological severity, thenar muscle atrophy, and preoperative grip strength have all been

found to be possible indicators of surgical results in earlier research [2]. Furthermore, reported disability after carpal tunnel surgery has been linked to socioeconomic criteria like income, education level, and immigration status [3].

About 71 million people worldwide are infected with the hepatitis C virus (HCV), which can induce a variety of extrahepatic symptoms in addition to liver illness. Of these, neurological problems are very prevalent, occurring in as many as 50% of patients with long-term HCV infection [4]. Peripheral nervous system involvement includes various forms of neuropathy, with a prevalence ranging from 22.5% in HCV mono-infected individuals to 44% in those with HIV co-infection [5].

The mechanisms underlying HCV-related peripheral neuropathy are primarily immune-mediated rather than resulting from direct viral invasion of nerve tissue [6]. These include vascular deposition of immune complexes and cryoglobulins leading to occlusion and ischemia of the vasa nervorum, necrotizing vasculitis induced by prolonged immune complex precipitation, perivascular inflammation causing nerve fiber damage and secondary demyelination, and axonal degeneration.

Given the significant impact of HCV on peripheral nerves and its potential effects on wound healing due to altered immune function, we hypothesized that HCV infection might influence the outcomes of carpal tunnel release surgery. However, this relationship remains largely unexplored in the literature. Therefore, this study aimed to investigate whether HCV infection affects the prognosis of carpal tunnel surgery by comparing outcomes between HCV-infected and non-infected patients.

METHODS

This prospective comparative study was conducted at the Neurosurgery Department, Faculty of Medicine, Zagazig University Hospitals, from April 2024 to April 2025.The sample size was determined based on the results of a pilot study conducted at the same department, which found success rates of 25% versus 87.5% in HCV carpal tunnel patients versus non-HCV carpal tunnel patients, respectively. Using Open Epi with a power of 80% and a confidence interval of 95%, the required sample size was calculated to be 24 patients. All patients gave their informed consent prior to surgery, and the study was approved by the Faculty of Medicine's research ethical council **(IRB# 279/7-April-2024)** at Zagazig University. The investigation was conducted in accordance with the Declaration of Helsinki, the World Medical Association's Code of Ethics for human studies.

Patients were selected after careful history taking, physical examination, and appropriate investigations. All patients received detailed counseling regarding the proposed plan, including necessary investigations, operative details, postoperative rehabilitation, and potential complications.

The study included 24 patients divided into two groups: an exposed group consisting of 12 CTS patients with untreated HCV infection and a non-exposed group consisting of 12 CTS patients without HCV infection matched for age and sex.

The inclusion criteria were all patients over the age of 18, referring to the sample population included neurosurgical clinics with CTS symptoms and a confirmed diagnosis of moderate to severe CTS based on history, physical examination, and electrophysiological studies. For the exposed group, these clinics included infection was verified without any prior therapy.

Exclusion criteria were comprehensive to eliminate confounding factors: patients with early or mild CTS, pregnancy,

malignancy, diabetes mellitus, Renal impairment, Hypothyroidism, Autoimmune or inflammatory disorders (such as multiple sclerosis and rheumatoid arthritis) Cervical disc prolapse with radiculopathy, Other hepatotropic viruses (A, B, D, and E), or other active infections (e.g., HIV/AIDS), Previous HCV treatment, Liver cell failure

Prior to surgery, all patients underwent a comprehensive evaluation. This included a general examination to assess their fitness for the procedure and a local examination of the involved hand and wrist to evaluate deformity, scarring, tender points, and range of motion. A thorough neurological examination was conducted, encompassing an assessment of motor, sensory, and reflex functions of both upper limbs, together with an assessment of nocturnal pain that is typified by numbness and tingling along the median nerve distribution. Certain provocative tests were also conducted, including Durkan's Test, which includes applying direct pressure over the carpal tunnel; Tinel's Sign, which involves tapping over the median nerve; and Phalen's Test, which requires maximal passive wrist flexion for 60 seconds. Patients completed self-assessment questionnaires detailing their personal history, including name, age, sex, occupation, and handedness, as well as their past and family medical history and clinical symptoms. Pain levels using a Visual Analogue Scale (VAS) reported by the patient, ranging from zero (no pain) to ten (maximum pain) [7].

Furthermore, a suite of laboratory investigations was carried out, including a complete blood count, liver enzymes (ALT, AST, ALP), kidney function tests, a lipid profile, and inflammatory markers such as ESR and CRP. Serum HCV antibodies were tested, with confirmatory PCR testing performed if positive, and fasting blood glucose levels were also measured.

Every patient had an electrophysiological and ultrasound diagnosis prior to surgery. The neurology department at Zagazig University employed the electrophysiological technique that was suggested by the American Association of Electrodiagnostic Medicine **(Jablecki et al., [8]).** Standardized nerve conduction measurement results were used, and the room's temperature was kept between 22 and 24 degrees Celsius throughout the procedures.

Study participants were graded using the Bland neurophysiological grading system for CTS:Grade 0 (Normal): All nerve conduction study results are within the normal range. Grade 1 (Very Mild): Abnormalities are only detectable with the most sensitive tests, such as the combined sensory index (CSI) or inching techniques. Grade 2 (Mild): Slowing of sensory nerve conduction velocity, but with a normal distal motor latency. Grade 3 (Moderate): Sensory potentials are preserved but show slowing, and there is also slowing of the distal motor latency (less than 6.5 ms). Grade 4 (Severe): Sensory potentials are absent, but the motor response is still present with a distal motor latency of less than 6.5 ms. Grade 5 (Very Severe): Characterized by a prolonged distal motor latency to the abductor pollicis brevis muscle of greater than 6.5 ms. Grade 6 (Extremely Severe): Both sensory and motor potentials are absent or effectively unrecordable (surface motor potential from the thenar muscles is less than 0.2 mV). [9].

All patients subsequently underwent open carpal tunnel release surgery. The choice of anesthesia was tailored to patient and surgeon preference, encompassing options such as WALANT, or Wide-Awake Local Anesthesia Without Tourniquet, regional anesthesia, monitored anesthesia care, or general anesthesia. The surgical technique began with positioning the patient with the affected arm extended on an arm

board, followed by the preparation and draping of the surgical site. An optional tourniquet could be applied before the administration of anesthesia. An imaginary line that extended proximally from the gap between the third and fourth digits was used to make an incision, usually 2 to 5 cm long. After that, the skin, subcutaneous fat, and palmar fascia were carefully dissected. Important structures were located and safeguarded, most notably the median nerve's palmar cutaneous branch. After the transverse carpal ligament was fully separated, the median nerve was examined. After achieving hemostasis, the incision was sealed and covered with a sterile dressing.

Postoperatively, patients received standard care, which included pain management, instructions for hand elevation to minimize swelling, and guidance on wound care. Follow-up evaluations were conducted at 2 weeks, 3 months, and 6 months after surgery. At each of these follow-up visits, assessments included an evaluation of any tingling or numbness, a pain assessment using the Visual Analogue Scale (VAS), and an assessment of wound healing.

Statistical Analysis

SPSS v26 was used to analyze the data (IBM©, Armonk, NY, USA). The Shapiro-Wilks test and histograms were used to assess the data distribution's normality. The unpaired student t-test was used to assess quantitative parametric data, which were displayed as mean and standard deviation (SD). The Mann-Whitney test was used to evaluate quantitative non-parametric data, which were displayed as the median and interquartile range (IQR). When applicable, the chi-square test or Fisher's exact test was used to examine the qualitative variables, which were displayed as frequency and percentage. To compare changes over time within groups, the Wilcoxon signed-rank test was employed. It was deemed statistically significant when the two-tailed p-value was less than 0.05.

RESULTS

Demographic data analysis revealed no statistically significant differences between the two patient groups regarding gender, age, or clinical criteria (Table 1).

Significant differences emerged in the persistence of tingling and pain between the two groups during the postoperative period. The non-HCV group shows significant improvement from preoperative to 2 weeks and 6 months postoperatively ($p<0.001$**), while the HCV group shows no significant change in the prevalence of tingling among patients over time. Pain levels assessed using the Visual Analogue Scale showed significant differences between the groups throughout the follow-up period. The non-HCV group shows significant improvement by 6 months compared to preoperative values ($p=0.002$*), while HCV group shows significant changes in pain levels at 2 weeks compared to preoperative values and at 6 months compared to 3 months ($p=0.046$*). (Table 2)

Postoperative nerve conduction studies (NCS) were performed on selected patients. While preoperative findings showed no significant differences, postoperative results revealed better improvement in the non-HCV group. And for wound healing, the non-HCV group showed significantly better healing after CTS surgery than the HCV group patients (Table 3).

Table (1): Comparison between the studied groups regarding demographic data and preoperative clinical findings

Variable	Non-HCV group (n=12)	HCV group (n=12)	Test value	P-value
Gender			Fisher	0.371
Female	**10 (83.3%)**	**7 (58.3%)**		
Male	**2 (16.7%)**	**5 (41.7%)**		
Age (years)			**t = -1.039**	**0.31**
Mean ± SD	**45.17 ± 8.77**	**49.42 ± 11.13**		
Thenar atrophy			**χ^2 = 0.168**	**0.682**
Absent	**6 (50%)**	**5 (41.7%)**		
Present	**6 (50%)**	**7 (58.3%)**		
Tinel sign			**Fisher**	**>0.999**
Absent	**2 (16.7%)**	**2 (16.7%)**		
Present	**10 (83.3%)**	**10 (83.3%)**		
Phalen sign			**Fisher**	**0.478**
Absent	**2 (16.7%)**	**0 (0%)**		
Present	**10 (83.3%)**	**12 (100%)**		

P>0.05 is meant non-significant.

Table (2). Comparison between the studied groups regarding clinical symptoms pre- and postoperatively.

Variable	Non-HCV group (n=12)	HCV group (n=12)	χ^2	P-value
Tingling				
Preoperative				>0.999
Present	12 (100%)	12 (100%)	0	
2 weeks postop				<0.001**
Absent	11 (91.7%)	0 (0%)	20.308	
Present	1 (8.3%)	12 (100%)		
3 months postop				<0.001**
Absent	11 (91.7%)	0 (0%)	20.308	
Present	1 (8.3%)	12 (100%)		
6 months postop				<0.001**
Absent	11 (91.7%)	3 (25%)	10.971	
Present	1 (8.3%)	9 (75%)		
Pain				
Preoperatively			0.168	0.682
Moderate	5 (41.7%)	6 (50%)		
Severe	7 (58.3%)	6 (50%)		
2 weeks postop			14.929	<0.001**
No pain	8 (66.7%)	0 (0%)		
Mild	1 (8.3%)	0 (0%)		
Moderate	3 (25%)	6 (50%)		
Severe	0 (0%)	6 (50%)		

Variable	Non-HCV group (n=12)	HCV group (n=12)	χ^2	P-value
3 months postop			16.657	<0.001**
No pain	9 (75%)	0 (0%)		
Mild	1 (8.3%)	0 (0%)		
Moderate	2 (16.7%)	6 (50%)		
Severe	0 (0%)	6 (50%)		
6 months postop			19.418	<0.001**
No pain	12 (100%)	0 (0%)		
Mild	0 (0%)	2 (16.7%)		
Moderate	0 (0%)	6 (50%)		
Severe	0 (0%)	4 (33.3%)		

P>0.05 is meant non-significant .*P<0.05 is meant significant.

Table (3): Comparison between the studied groups regarding NCS finding and healing pre- and postoperatively.

	Non-HCV group (n=12)	HCV group (n=12)	Test value	P
NCS				
Preoperatively			0.686	0.408
Moderate	4 (33.3%)	6 (50%)		
Severe	8 (66.7%)	6 (50%)		
Postoperatively			Fisher	0.009*
Normal	0 (0%)	11 (91.7%)		
Mild	3 (100%)	1 (8.3%		
Healing			8.224	0.004*
Normal	10 (83.3%)	3 (25%)		
Delayed	2 (16.7%)	9 (75%)		

P>0.05 is meant non-significant .*P<0.05 is meant significant.

DISCUSSION

This study investigated the impact of HCV infection on the outcome of carpal tunnel release surgery. Despite similar demographic characteristics and preoperative clinical findings between the HCV and non-HCV groups, significant differences emerged in postoperative outcomes, including persistence of tingling, pain resolution, wound healing, and improvement in nerve conduction studies.

One of the most striking findings of our study was the significant difference in the persistence of tingling between the two groups. At 6 months postoperatively, 75% of patients in the HCV group continued to experience tingling compared to only 8.3% in the non-HCV group (p<0.001). Similarly, pain assessment using the Visual Analogue Scale revealed that all patients in the non-HCV group achieved complete pain resolution by 6 months, while all HCV patients continued to experience varying degrees of pain, with 83.3% reporting moderate to severe pain.

These findings align with the current understanding of the neurological manifestations of HCV infection. Previous studies have reported that 40-75% of HCV-positive patients experience peripheral neuropathy, particularly those with cryoglobulinemia [6]. The persistence of symptoms in HCV patients following carpal tunnel release may be attributed to the underlying pathophysiological mechanisms of HCV-related peripheral nerve damage rather than mere mechanical compression of the median nerve.

HCV is believed to affect peripheral nerves primarily through immune-mediated processes rather than direct viral invasion. These mechanisms include vascular deposition of immune complexes leading to occlusion of the vasa nervorum, necrotizing vasculitis induced by immune complex precipitation, and subsequent ischemia and inflammation of nerve fibers [5]. These processes may continue to affect the median nerve even after surgical decompression, contributing to the persistence of symptoms observed in our HCV cohort.

Another significant finding was the markedly higher rate of delayed wound healing in the HCV group (75%) compared to the non-HCV group (16.7%) (p=0.004). This observation supports the hypothesis that HCV infection may impair the wound healing process.

The underlying mechanisms might involve HCV-induced alterations in immune function, including chronic inflammation, dysregulation of cytokine production, and impaired tissue repair processes. Chronic HCV infection is known to induce a state of persistent inflammation and immune activation, which can disrupt the normal sequence of wound healing events [7]. Additionally, HCV-related cryoglobulinemia and vasculitis may compromise microcirculation, further impairing tissue repair.

Our findings on nerve conduction studies further support the different outcomes between HCV and non-HCV patients. While both groups showed improvement compared to their preoperative status, the non-HCV group demonstrated better recovery, with all tested patients achieving either normal or mild nerve conduction abnormalities postoperatively. In contrast, the majority of tested HCV patients continued to exhibit moderate to severe abnormalities.

These electrophysiological findings correlate with the clinical observations of persistent symptoms in the HCV group and suggest that the underlying HCV-related neuropathic process may limit the extent of recovery following surgical decompression.

This is the first study specifically investigating the impact of HCV infection on carpal tunnel surgery outcome at Zagazig University Hospitals. Previous research has identified various factors affecting the prognosis of carpal tunnel release, considering preoperative grip strength, thenar muscle atrophy, electrophysiological severity, age, and length of symptoms [2]. Perceived incapacity after surgery has also been linked to socioeconomic criteria like income, immigration status, and educational attainment [3].

Our findings add HCV infection to this list of prognostic factors and highlight its significant impact on multiple outcome measures. The mechanisms underlying these poorer outcomes likely involve the complex interplay between HCV-related peripheral nerve damage and impaired wound healing processes.

Clinical Implications

The findings of this study have significant clinical ramifications since patients with carpal tunnel syndrome, especially those with severe or unusual symptoms, may benefit from HCV screening. Patients with HCV infection should be counseled about the potentially poorer prognosis following carpal tunnel release surgery, including higher rates of persistent symptoms and delayed wound healing. Alternative or adjunctive treatment strategies might be considered for HCV patients with carpal tunnel syndrome, potentially including antiviral therapy before surgical intervention. More observant postoperative monitoring and extended follow-up may be necessary for HCV-infected patients undergoing carpal tunnel release.

Limitations and Future Directions

It is important to recognize the various limitations of this study. First, despite being statistically sufficient according to power calculations, the sample size is somewhat tiny. To validate these results and investigate possible subgroup variations, larger investigations are required.

Second, the follow-up period of 6 months, while standard for many surgical outcome studies, may not be sufficient to assess long-term outcome. Future research should include longer follow-up periods to determine whether the differences observed persist over time or if the HCV group eventually achieves comparable outcomes with a delayed timeline.

Third, this study did not assess the impact of HCV viral load or genotype on surgical

outcomes, nor did it evaluate the potential benefit of antiviral therapy prior to surgery. These represent important areas for future investigation.

Finally, detailed immunological and molecular studies would be valuable to elucidate the precise mechanisms by which HCV infection affects carpal tunnel surgery outcomes, potentially identifying targets for intervention to improve results in this patient population.

Conclusion

This study demonstrates that HCV infection significantly impacts the prognosis of carpal tunnel surgery, resulting in higher rates of persistent symptoms, delayed wound healing, and poorer improvement in nerve conduction studies compared to non-HCV patients. These findings suggest that HCV status should be considered an important prognostic factor when planning carpal tunnel release surgery.

These results emphasize the significance of taking HCV status into account when treating carpal tunnel syndrome in clinical practice and imply that a more thorough strategy could be required for the best results in this patient group.

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