NICOLAUS COPERNICUS UNIVERSITY IN TORUŃ

Quality in Sport. eISSN 2450-3118.

Journal Home Page
https://apcz.umk.pl/QS/index

PONIEWOZIK Piotr, DZIUBA Natalia, SIM Aleksandra, PERNAL Maja, ROGUSKA Zofia, ZUZAK Andrzej Paweł, PONIEWOZIK Paweł, GRABOWSKI Krzysztof, MIODUSZEWSKA Joanna, ROT Paweł. Modern Non-Surgical Management of Carpal Tunnel Syndrome: Mechanisms, Clinical Evidence and Therapeutic Potential: A Literature Review. Quality in Sport. 2026;54:70719. eISSN 2450-3118. https://doi.org/10.12775/QS.2026.54.70719

The journal has been awarded 20 points in the parametric evaluation by the Ministry of Higher Education and Science of Poland. This is according to the Annex to the announcement of the Minister of Higher Education and Science dated 05.01.2024, No. 32553. The journal has a Unique Identifier: 201398. Scientific disciplines assigned: Economics and Finance (Field of Social Sciences); Management and Quality Sciences (Field of Social Sciences).
Punkty Ministerialne z 2019 - aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398. Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych).
The authors declare that there is no conflict of interest regarding the publication of this paper.
Received: 10.04.2026. Revised: 15.04.2026. Accepted: 15.04.2026. Published: 23.04.2026.

Modern Non-Surgical Management of Carpal Tunnel Syndrome: Mechanisms, Clinical Evidence and Therapeutic Potential: A Literature Review

Piotr Poniewozik

Medical University of Lublin, Aleje Racławickie 1, 20-059 Lublin, Poland

piotr.poniewozik01@gmail.com

https://orcid.org/0009-0001-6350-4981

Natalia Dziuba

Medical University of Lublin, Aleje Racławickie 1, 20-059 Lublin, Poland

nat.dziuba@gmail.com

https://orcid.org/0009-0002-4719-9208

Aleksandra Sim

Medical University of Lublin, Aleje Racławickie 1, 20-059 Lublin, Poland

misardnaskela@gmail.com

https://orcid.org/0009-0001-6475-4595

Maja Pernal

Medical University of Lublin, Aleje Racławickie 1, 20-059 Lublin, Poland

pernalmaja@gmail.com

https://orcid.org/0009-0003-9616-2361

Zofia Roguska

Medical University of Lublin, Aleje Racławickie 1, 20-059 Lublin, Poland

zosia.roguska@gmail.com

https://orcid.org/0009-0007-8588-2784

Andrzej Pawel Zuzak

Medical University of Lublin, Aleje Racławickie 1, 20-059 Lublin, Poland

andrzejzuzak1@gmail.com

https://orcid.org/0009-0008-6578-1457

Paweł Poniewozik

Medical University of Lublin, Aleje Racławickie 1, 20-059 Lublin, Poland

poniewozikpawel01@gmail.com

https://orcid.org/0009-0006-2057-2219

Krzysztof Grabowski

Dr. Tytus Chałubiński Radom Specialist Hospital, Adolfa Tochtermana 1 Street, 26-610 Radom, Poland

krzysztofgrabowski444@gmail.com

https://orcid.org/0009-0004-1482-7188

Joanna Mioduszewska

Medical University of Lublin, Aleje Racławickie 1, 20-059 Lublin, Poland

asia.mioduszewska01@gmail.com

https://orcid.org/0009-0001-1024-1217

Paweł Rot

Medical University of Lublin, Aleje Racławickie 1, 20-059 Lublin, Poland

pawel_rot@outlook.com

https://orcid.org/0009-0004-4140-4463

Abstract

Background: Carpal tunnel syndrome (CTS) is the most prevalent entrapment neuropathy and represents a major functional and socioeconomic burden. Although surgical decompression remains the gold standard for advanced disease, current guidelines emphasize non-invasive management in mild-to-moderate CTS. This has stimulated rapid development of novel therapeutic strategies aimed at reducing median nerve compression, modulating inflammation, and supporting neural regeneration.

Aim of the study: To provide a comprehensive review of contemporary non-surgical methods used in CTS treatment, including extracorporeal shock wave therapy (ESWT), low-level laser therapy (LLLT), ultrasound-based interventions, as well as platelet-rich plasma (PRP) injections, and to assess their mechanisms, clinical efficacy and potential therapeutic relevance.

Methodology: The review was conducted using PubMed, Google Scholar and Research Gate databases, focusing on peer-reviewed literature published between 2021 and 2026.

Results: The study shows that ESWT provides only short-term symptom relief, while the clinical effects of LLLT remain inconsistent due to variable treatment parameters. Ultrasound-based therapies-particularly USG-guided techniques-offer clearer improvements in symptoms, function, and procedural safety. Among all evaluated methods, PRP demonstrates the most substantial therapeutic and regenerative potential, that surpass those achieved with corticosteroid injections.

Conclusions: Modern conservative interventions differ considerably in effectiveness and mechanisms of action. While ESWT and LLLT may serve as supportive therapies, ultrasound-based methods-particularly USG-guided techniques-and PRP injections display superior therapeutic value. Despite encouraging results, further high-quality, long-term randomized trials are needed to standardize treatment protocols and confirm the comparative effectiveness of these methods.

Keywords: carpal tunnel syndrome, conservative treatment, platelet-rich plasma, peripheral neuropathy, neuromodulation,

1. Introduction

Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy, constituting 90% of all neuropathy cases.[1] Entrapment neuropathy is a localized chronic condition caused by elevated pressure within rigid anatomical spaces. Carpal tunnel syndrome results from compression of the median nerve within the carpal tunnel, bounded by the carpal bones and the transverse carpal ligament, leading to increased intracarpal pressure and impaired nerve function.[2] Patients with carpal tunnel syndrome commonly experience pain, paresthesia, sensory disturbances, and weakness of the hand and wrist, which consequently leads to decreased physical fitness and limitations in performing daily activities.[3] However, there is no confirmed correlation between the presence and severity of symptoms and the severity of CTS.[4] CTS is diagnosed primarily based on a clinical examination and tests assessing

median nerve function (sensory and motor), as well as nerve conduction studies, with ultrasound also used as an accessory tool.[5] The aetiology of CTS can be related to work, lifestyle, injury, or genetic predisposition. Repetitive movements, exposure to vibration, and forceful wrist activity are the most common causes, while conditions such as diabetes, pregnancy, and obesity further increase the risk.[6] The worldwide incidence of CTS ranges from 3% to 4% and is generally reported to be more common in females.[7] In addition, it has been shown that the first symptoms of carpal tunnel syndrome appear in women at a younger age than in men, usually between the ages of 45 and 54, whereas in men they are more common between the ages of 75 and 84. Furthermore, white people are more likely to develop this condition than black people.[8] In recent years, there has been an increase in the prevalence of CTS, which is linked both to an aging population and to widespread exposure to repetitive strain resulting from occupational activities and daily life. Epidemiological reviews confirm that this syndrome represents a growing health and economic burden on healthcare systems worldwide.[3]

In the treatment of CTS, both conservative methods and surgical procedures are traditionally used. In cases of significant symptom intensity, treatment should focus on reducing pressure on the median nerve. Although surgical release of the carpal tunnel is effective, it is associated with high costs, a long recovery period, and a risk of complications.[9] According to current guidelines, conservative treatment is recommended as the treatment of choice for patients experiencing occasional symptoms and showing no evidence of permanent nerve damage.[10] Given the wide variety of available methods and the ever-increasing number of clinical trials, it has become necessary to conduct an up-to-date, systematic review of the literature to assess the efficacy, safety, and clinical application of modern, non-surgical therapeutic strategies for the treatment of carpal tunnel syndrome. This article aims to provide a comprehensive overview of the current scientific evidence and identify the methods with the greatest therapeutic potential.

2. Methodology

This article presents a narrative, evidence-based review of modern non-invasive and minimally invasive treatments for carpal tunnel syndrome (CTS), including ESWT, LLLT, therapeutic ultrasound, ultrasound-guided interventions, and platelet-rich plasma (PRP). A structured literature search was conducted using the PubMed, Research Gate and Google Scholar to identify relevant articles published between 2021 and 2026. Search terms included carpal tunnel syndrome, median nerve, shock wave, low-level laser, ultrasound therapy, ultrasound-guided injection, and platelet-rich plasma.

3. Extracorporeal Shock Wave Therapy

Extracorporeal shockwave therapy (ESWT) is one of the modern, non-invasive methods for treating carpal tunnel syndrome, and has been gaining increasing attention in recent years. This method involves the application of high-energy acoustic waves to the affected tissues, which leads to a series of biological effects that promote regeneration. Although the exact mechanism of action of ESWT has not been fully elucidated, available data suggest that

shock waves may induce a number of biological processes, such as: stimulation of tissue regeneration, enhancement of angiogenesis in soft tissues, acceleration of calcification resorption, and modulation of nerve conduction through their effect on local nociceptors.[11], [12], [13], [14] Two main types of shock waves are used in the treatment of carpal tunnel syndrome. Focused shock waves (fESWT) penetrate deeper, allowing for more precise targeting of the median nerve, while radial shock waves (rESWT) act more superficially and are scattered within the tissues.[15] Radial shock wave therapy appears to be more effective than focused shock wave therapy in reducing symptoms and improving hand function in patients with carpal tunnel syndrome.[16] The use of radial ESWT combined with standard physiotherapy has been shown to alleviate symptoms, enhance functional outcomes, and improve nerve conduction parameters, including conduction velocity and distal motor latency, in patients with mild-to-moderate CTS.[17] Based on a randomized, double-blind, placebo-controlled study involving 45 patients, Menekseoglu et al. demonstrated that rESWT has beneficial effects in reducing pain, improving hand function, and enhancing electrophysiological parameters in patients with mild-to-moderate CTS already after 1 month of treatment.[14] A study conducted by Habibzadeh et al. evaluated the short-term effect of radial shockwave therapy on the course of the median nerve in patients with mild to moderate carpal tunnel syndrome. The randomized controlled clinical trial included 60 patients divided into 3 groups. All groups were provided with standard physical therapy, and two groups additionally received four sessions of radial shockwave therapy. Pain, paresthesia, nerve conduction parameters, and BCTQ (The Boston Carpal Tunnel Questionnaire) scores were assessed at the start of therapy and after 1 and 4 weeks. Clinical improvement was observed in all groups, but it was more prominent in patients treated with shockwave therapy. Improvement in electrophysiological parameters was observed exclusively in the shockwave therapy treatment groups.[18] In an analysis of 7 randomized clinical trials involving 376 patients published by Chen et al., the efficacy and safety of ESWT were compared with those of orthosis use alone. The results showed that significant functional improvement and symptom relief occurred only four weeks after therapy in the ESWT group; at 8–10 and 12–14 weeks, no advantage of ESWT over orthosis alone was observed. The therapeutic effect of ESWT turned out to be temporary and mostly insignificant compared to treatment with a splint. No serious side effects were reported in any of the studies.[19] ESWT therefore appears to be a helpful but not groundbreaking method for treating CTS.

4. Low-Level Laser Therapy

Low-Level Laser Therapy (LLLT), also known as photobiomodulation, is a non-invasive therapeutic method that uses low-power laser or LED light, which does not produce a thermal effect in tissues but works through photochemical and photobiological processes. Low-level laser therapy (LLLT) exerts a photochemical effect on cells, leading to accelerated electron transport in the mitochondrial respiratory chain and increased ATP synthesis, as well as modifications in redox status resulting in reduced oxidative stress and the activation of transcriptional pathways regulating the reparative and anti-inflammatory response. Consequently, LLLT exhibits anti-inflammatory and cytoprotective effects, supports the regeneration of tissues and nerve fibers, and further reduces pain intensity and limits tissue

damage.[20] A meta-analysis conducted by Bekhet et al. evaluated the efficacy of low-level laser therapy (LLLT) in the treatment of mild to moderate carpal tunnel syndrome. The study included eight randomized trials involving 473 patients (631 wrists), comparing LLLT—used alone or in combination with wrist stabilization—with a placebo. The results showed that laser therapy was more effective than placebo in improving grip strength; however, no significant differences were observed between the groups in terms of improvements in functional ability, pain relief, or motor nerve conduction test results.[21] In the study comparing low-level laser therapy (LLLT) and corticosteroid injection in patients with moderate carpal tunnel syndrome, Güloğlu and colleagues demonstrated that, in the short term (after 1 month), better results were achieved in the corticosteroid group. However, after 6 months, no significant differences were found between the methods. Both therapies led to an improvement in clinical symptoms and functional parameters, although an improvement in sensory conduction was mainly observed in the corticosteroid group.[22] Current research findings do not provide a clear answer regarding the effectiveness of LLLT in the treatment of CTS, or whether this form of treatment offers any advantage over conventional methods such as physiotherapy, the use of stabilising braces or the use of corticosteroids. Among the main potential benefits of LLLT are improved grip strength and improvements in neurophysiological parameters. However, there are also studies that cast doubt on the beneficial effects of LLLT in improving the quality of life for patients with CTS by alleviating symptoms such as pain, fatigue, and discomfort.[23]

5. The use of ultrasound techniques

Ultrasound therapy has the potential to be one of the most commonly used non-invasive physical therapy methods for treating carpal tunnel syndrome (CTS), especially in patients seeking symptom relief without the risks associated with invasive procedures. The mechanism of action of ultrasound involves both mechanical and biochemical effects—including improved microcirculation, reduced swelling, and stimulation of regenerative processes within the median nerve and surrounding tissues. Scientists also highlight their role in modulating nerve conduction by influencing local inflammatory processes and activating cellular metabolism.[24] Therapeutic ultrasound is effective in treating CTS symptoms when used for 4–8 weeks (at least twice a week), and its effects can last up to a year also it can be used at any stage of the disease.[25] A systematic review by Ahmad et al. (2024), which covers studies on the use of ultrasound in the treatment of CTS in women, also makes a significant contribution to the assessment of ultrasound's efficacy. The authors demonstrated that ultrasound therapy leads to a significant improvement in pain reduction and hand function, as assessed by everyday activity tests. Although the treatment parameters varied across some of the studies, the analysis confirmed the beneficial effects of ultrasound as an intervention with proven effects at the neuromuscular and functional levels.[26] One of the leading research projects on the use of ultrasound therapy is the USTINCTS trial, whose protocol was described in BMJ Open (2024). It is a multicenter, randomized study conducted by Chen and colleagues in which patients were randomly assigned to one of three treatment groups based on the treatment method used: therapeutic ultrasound, a night splint, and combined therapy (ultrasound + splint). The aim of the study is to examine the effect of

ultrasound on symptom severity as assessed by the BCTQ and to compare the results with standard treatment. This study highlights the ongoing need to evaluate the effectiveness of ultrasound in the treatment of CTS in clinical practice.[27]

At the same time, the use of ultrasound as an adjunct in the treatment of CTS-serving as a guiding tool during invasive procedures is gaining recognition. Thanks to its high resolution, ultrasound imaging allows for a precise assessment of the structures within the carpal tunnel, including the median nerve, the flexor retinaculum, and the tendon sheaths, enabling an accurate determination of the level of compression and the recognition of any associated pathologies. A review published in the British Journal of Radiology (2023) highlighted that ultrasound-guided techniques, such as perineural steroid injections and hydrodissection, are more effective and safer than methods performed without image guidance. Ultrasound allows for continuous visualization of the needle and the median nerve, which minimizes the risk of nerve damage and increases the precision of drug delivery, leading to more effective reduction of inflammation and improved nerve mobility.[28] Significant clinical evidence supporting the value of ultrasound as an adjunctive method also comes from a meta-analysis by Lam et al. (2023). An analysis of 20 studies showed that ultrasound-guided steroid injections demonstrate greater therapeutic efficacy compared to injections guided by palpation, both in terms of pain reduction and improvement in hand function. In addition, procedures such as ultrasound-guided percutaneous transverse carpal ligament release allow the surgery to be performed with minimal tissue trauma, a shorter recovery time, and a lower risk of complications compared to standard surgical procedures.[7] Further clinical evidence supporting the efficacy of ultrasound-guided treatment comes from a study by Kamel et al. (2021), who demonstrated that ultrasound-guided percutaneous release of the flexor retinaculum significantly improves hand function and reduces symptom severity in both the short and long term. The analysis included 61 procedures performed on 46 patients. Hand function and symptom severity were assessed using the QDASH, BCTSQ-SS, and BCTSQ-FS questionnaires before the procedure, 2 weeks later, and at least one year after the intervention. The results showed that a significant improvement was observed just two weeks after the procedure. All functional and symptomatic measures showed a significant reduction compared to initial values. In the long-term follow-up (median 1.7 years), further improvement was noted, and in over 95% of patients, QDASH and BCTSQ scores were lower than before the procedure. The authors point out that visualizing anatomical structures makes it possible to perform the procedure with greater precision and in a less invasive form than with the traditional method, which results in less postoperative pain and a faster return to normal activities.[29]

6. Platelet-rich plasma

Platelet-rich plasma (PRP) is one of the most promising biological treatments for carpal tunnel syndrome (CTS). The mechanism of action of platelet-rich plasma (PRP) in the treatment of carpal tunnel syndrome is complex and involves simultaneous effects on the microenvironment of the median nerve, the inflammatory response, and regenerative processes. In the literature on peripheral nerve injuries, PRP is described as a biological stimulator that, thanks to its high concentration of growth and neurotrophic factors-such as

PDGF, VEGF, TGF-β, and IGF-1-creates an environment conducive to axonal regeneration, Schwann cell proliferation, and extracellular matrix remodeling. The review by Shang et al. (2025) highlights that these factors promote axonal growth, reduce the formation of fibrous scar tissue, and activate nerve support cells, leading to improved sensory and motor function following peripheral nerve injuries.[30] Another key aspect of PRP's mechanism of action is its effect on the inflammatory process. Long-lasting inflammation in the carpal tunnel contributes to swelling and the deterioration of median nerve conduction. A review by Dou and An (2025) indicated that PRP reduces the expression of pro-inflammatory cytokines while simultaneously activating cellular pathways associated with tissue repair, leading to the restoration of balance between damage and regeneration processes. By improving angiogenesis and tissue nutrition, PRP restores the nerve's cellular microenvironment, which promotes its functional regeneration.[31] The highest level of evidence regarding the efficacy of PRP is represented by the meta-analysis by Jiang et al. (2022), which included eight randomized clinical trials (involving 220 patients). The authors demonstrated that, compared to other conservative methods, PRP significantly improves patients' clinical condition, particularly in the medium term. A significant reduction in symptom severity, improvement in hand function, reduction in median nerve cross-sectional area, and improvement in selected electrophysiological parameters were observed. Importantly, PRP resulted in better outcomes than steroid injections, wrist immobilization, and placebo treatment in terms of improving CTS function and symptoms.[32] Information on the long-term efficacy of PRP therapy is also important. A study by Lai et al. (2022) showed that a single perineural injection can provide pain relief that lasts for more than two years in approximately 70% of patients. Better outcomes were observed in patients with a shorter duration of the condition and less severe electrophysiological symptoms, suggesting that PRP therapy appears to be most effective in the early stages of CTS.[33] A comparative analysis of 19 randomized trials involving 1,066 patients compared the efficacy of various injection therapies used for CTS, including PRP, steroids, dextrose solutions, estrogens, and hydroxyprogesterone. The authors examined three key clinical outcomes: pain intensity (VAS), symptom severity (SSS), and functional limitations (FSS). A SUCRA ranking analysis showed that PRP injections were not the most effective method for pain reduction, with 5% dextrose and high-dose steroids offering more benefits. Nevertheless, PRP ranked third in terms of pain reduction, indicating a significant clinical effect. In terms of reducing symptom severity, PRP ranked as one of the most effective methods, surpassed only by steroids and estrogen. Similar to the improvement in hand function measured using the FSS, where the highest efficacy was observed with hydroxyprogesterone, PRP ranked among the leading therapeutic methods and demonstrated a clear advantage over traditional conservative strategies.[34] Despite a growing amount of research confirming the efficacy of platelet-rich plasma (PRP) in the treatment of carpal tunnel syndrome (CTS), this method still has significant limitations that make it difficult to clearly establish its place in treatment algorithms. One of the main problems is the lack of standardization in PRP preparation and administration protocols. Differences exist in the number and duration of centrifugation cycles, platelet concentration, volume, and the injection technique itself, resulting in significant heterogeneity in outcomes and making it difficult to compare individual studies. In a review by Malahias et al., it was emphasized that

this method requires further standardization in order to clearly define the optimal therapeutic protocol for patients with CTS.[35]

7. Discussion

This study compares four modern, non-invasive treatments for carpal tunnel syndrome (CTS): extracorporeal shock wave therapy (ESWT), low-level laser therapy (LLLT), ultrasound techniques—both conventional and ultrasound-guided—and platelet-rich plasma (PRP). An analysis of the available data indicates that all of these methods may offer clinical benefits; however, they differ in their mechanism of action, the consistency of their effects, and the strength of the scientific evidence supporting their efficacy. ESWT therapy provides short-term pain relief and improves hand function and electrophysiological parameters, although the quality of the evidence is moderate and the duration of the effect is limited.[15] LLLT has a beneficial effect on cellular metabolism and the modulation of inflammation but clinical trial results remain inconsistent due to the heterogeneity of treatment protocols, making it difficult to clearly confirm the superiority of this method over other physical therapy modalities.[36] Ultrasound techniques-particularly ultrasound-guided procedures-deliver the most predictable results, offering high precision, safety, and significant improvements in function and symptoms. Their advantage over methods performed without image guidance means that ultrasound plays a key role both as a therapeutic modality and as a tool to assist with injection procedures.[7], [29] Among the methods mentioned, platelet-rich plasma (PRP) appears to be the most promising therapy. PRP combines anti-inflammatory, neuroprotective, and regenerative effects, which translate into a lasting reduction in symptoms, improved hand function, and favorable changes in electrophysiological parameters. The latest network meta-analyses indicate that PRP outperforms steroids in long-term follow-up and ranks among the top treatments for CTS injection therapy.[37] Importantly, the observed clinical effects persist for up to several years after the procedure, particularly in patients with mild and moderate forms of CTS, as confirmed in prospective studies.[33]

In summary, ESWT and LLLT can serve as valuable adjuncts to conservative therapy, while ultrasound—particularly ultrasound-guided techniques—offers the highest precision and safety among non-surgical methods. PRP remains the only treatment with proven regenerative effects and documented short- and long-term efficacy, making it the most promising among the therapies analyzed for the treatment of mild and moderate forms of CTS.

8. Conclussion

Modern conservative interventions differ considerably in effectiveness and mechanisms of action. While ESWT and LLLT may serve as supportive therapies, ultrasound-based methods—particularly USG-guided techniques—and PRP injections display superior therapeutic value. PRP emerges as the most promising biological option for patients with mild-to-moderate CTS due to its regenerative profile and durable clinical effects. Despite

encouraging results, further high-quality, long-term randomized trials are needed to standardize treatment protocols and confirm the comparative effectiveness of these methods.

Disclosure:

Author Contribution Statement:

Conceptualization: Piotr Poniewozik, Joanna Mioduszewska, Paweł Rot, Aleksandra Sim

Methodology: Piotr Poniewozik, Zofia Roguska, Paweł Poniewozik

Formal analysis: Andrzej Paweł Zuzak, Natalia Dziuba

Investigation: Piotr Poniewozik, Joanna Mioduszewska, Paweł Rot, Natalia Dziuba, Andrzej Paweł Zuzak, Aleksandra Sim, Paweł Poniewozik, Zofia Roguska, Maja Pernal, Krzysztof Grabowski

Resources: Piotr Poniewozik

Data curation: Piotr Poniewozik, Joanna Mioduszewska, Maja Pernal, Krzysztof Grabowski

Writing -rough preparation: Piotr Poniewozik, Joanna Mioduszewska, Paweł Rot, Natalia Dziuba, Andrzej Paweł Zuzak, Aleksandra Sim, Paweł Poniewozik, Zofia Roguska, Maja Pernal, Krzysztof Grabowski

Writing–review and editing: Piotr Poniewozik, Paweł Rot, Maja Pernal

Visualization: Zofia Roguska, Natalia Dziuba

Supervision: Piotr Poniewozik, Paweł Poniewozik, Aleksandra Sim

Project administration: Piotr Poniewozik

All authors have read and agreed with the published version of the manuscript.

Funding statement:

No external funding was received to perform this review

Institutional Review Board Statement:

Not applicable

Informed ConsentStatement:

Not applicable

Data Availability Statement:

Not applicable

Conflict of Interest Statement:

The authors declare no conflict of interest.

[1] J. O. Sevy, R. E. Sina, i M. A. Varacallo, „Carpal Tunnel Syndrome”, w *StatPearls*, Treasure Island (FL): StatPearls Publishing, 2026. Dostęp: 9 kwietnia 2026. [Online]. Dostępne na: http://www.ncbi.nlm.nih.gov/books/NBK448179/

[2] I. Ibrahim, W. S. Khan, N. Goddard, i P. Smitham, „Carpal tunnel syndrome: a review of the recent literature”, *Open Orthop. J.*, t. 6, s. 69–76, 2012, doi: 10.2174/1874325001206010069.

[3] S. Jiménez-Del-Barrio *et al.*, „The effectiveness of manual therapy on pain, physical function, and nerve conduction studies in carpal tunnel syndrome patients: a systematic review and meta-analysis”, *Int. Orthop.*, t. 46, nr 2, s. 301–312, lut. 2022, doi: 10.1007/s00264-021-05272-2.

[4] V. Scalise, F. Brindisino, L. Pellicciari, S. Minnucci, i F. Bonetti, „Carpal Tunnel Syndrome: A National Survey to Monitor Knowledge and Operating Methods”, *Int. J. Environ. Res. Public. Health*, t. 18, nr 4, s. 1995, lut. 2021, doi: 10.3390/ijerph18041995.

[5] A. Peris Moya, J. M. Pérez Mármol, E. F. Khoury Martín, i M. C. García Ríos, „Ultrasound improves motor distal latency on patients with carpal tunnel syndrome: systematic review and meta-analysis”, *Eur. J. Phys. Rehabil. Med.*, t. 58, nr 2, s. 206–217, kwi. 2022, doi: 10.23736/S1973-9087.21.07021-0.

[6] K. Osiak, P. Elnazir, J. A. Walocha, i A. Pasternak, „Carpal tunnel syndrome: state-of-the-art review”, *Folia Morphol.*, t. 81, nr 4, s. 851–862, 2022, doi: 10.5603/FM.a2021.0121.

[7] K. H. S. Lam, Y.-T. Wu, K. D. Reeves, F. Galluccio, A. E.-S. Allam, i P. W. H. Peng, „Ultrasound-Guided Interventions for Carpal Tunnel Syndrome: A Systematic Review and Meta-Analyses”, *Diagnostics*, t. 13, nr 6, s. 1138, mar. 2023, doi: 10.3390/diagnostics13061138.

[8] M. Malakootian, M. Soveizi, A. Gholipour, i M. Oveisee, „Pathophysiology, Diagnosis, Treatment, and Genetics of Carpal Tunnel Syndrome: A Review”, *Cell. Mol. Neurobiol.*, t. 43, nr 5, s. 1817–1831, lip. 2023, doi: 10.1007/s10571-022-01297-2.

[9] H. A. Abdolrazaghi, M. Khansari, M. Mirshahi, i M. Ahmadi Pishkuhi, „Effectiveness of Tendon and Nerve Gliding Exercises in the Treatment of Patients With Mild Idiopathic Carpal Tunnel Syndrome: A Randomized Controlled Trial”, *Hand*, t. 18, nr 2, s. 222–229, mar. 2023, doi: 10.1177/15589447211006857.

[10] I. Kjeken i U. Sundin, „Management of carpal tunnel syndrome in primary care”, *Rheumatology*, t. 62, nr 2, s. 495–496, lut. 2023, doi: 10.1093/rheumatology/keac396.

[11] H. De la Corte-Rodríguez, J. M. Román-Belmonte, B. A. Rodríguez-Damiani, A. Vázquez-Sasot, i E. C. Rodríguez-Merchán, „Extracorporeal Shock Wave Therapy for the Treatment of Musculoskeletal Pain: A Narrative Review”, *Healthcare*, t. 11, nr 21, s. 2830, paź. 2023, doi: 10.3390/healthcare11212830.

[12] G. Sağlam, D. Çetinkaya Alişar, i S. Özen, „Physical therapy versus radial extracorporeal shock wave therapy in the treatment of carpal tunnel syndrome: A randomized-controlled study”, *Turk. J. Phys. Med. Rehabil.*, t. 68, nr 1, s. 126–135, mar. 2022, doi: 10.5606/tftrd.2022.7187.

[13] A. S. Tenforde *et al.*, „Best practices for extracorporeal shockwave therapy in musculoskeletal medicine: Clinical application and training consideration”, *PM R*, t. 14, nr 5, s. 611–619, maja 2022, doi: 10.1002/pmrj.12790.

[14] A. K. Menekseoglu, M. D. Korkmaz, i H. Segmen, „Clinical and electrophysiological efficacy of extracorporeal shock-wave therapy in carpal tunnel syndrome: a placebo-controlled, double-blind clinical trial”, *Rev. Assoc. Med. Bras.*, t. 69, nr 1, s. 124–130, 2023, doi: 10.1590/1806-9282.20220943.
[15] L. Zhang *et al.*, „Effects of Extracorporeal Shock Wave Therapy in Patients with Mild-to-Moderate Carpal Tunnel Syndrome: An Updated Systematic Review with Meta-Analysis”, *J. Clin. Med.*, t. 12, nr 23, s. 7363, lis. 2023, doi: 10.3390/jcm12237363.
[16] Y. Xie *et al.*, „Effects of shock wave therapy in patients with carpal tunnel syndrome: a systematic review and meta-analysis”, *Disabil. Rehabil.*, t. 44, nr 2, s. 177–188, sty. 2022, doi: 10.1080/09638288.2020.1762769.
[17] A. M. Hassan, S. M. Mohammed Kamel, E. Aboelnasr, F. A. Hegazy, R. A. Elkalla, i M. A. Raafat, „Comparison of Extracorporeal Radial Shock Wave Different Doses On Carpal Tunnel Syndrome: A Preliminary Study”, *NeuroRehabilitation*, t. 58, nr 2, s. 293–301, mar. 2026, doi: 10.1177/10538135251407693.
[18] A. Habibzadeh, R. Mousavi-Khatir, P. Saadat, i Y. Javadian, „The effect of radial shockwave on the median nerve pathway in patients with mild-to-moderate carpal tunnel syndrome: a randomized clinical trial”, *J. Orthop. Surg.*, t. 17, nr 1, s. 46, sty. 2022, doi: 10.1186/s13018-022-02941-9.
[19] K.-T. Chen, Y.-P. Chen, Y.-J. Kuo, i M.-H. Chiang, „Extracorporeal Shock Wave Therapy Provides Limited Therapeutic Effects on Carpal Tunnel Syndrome: A Systematic Review and Meta-Analysis”, *Medicina (Mex.)*, t. 58, nr 5, s. 677, maja 2022, doi: 10.3390/medicina58050677.
[20] M. Berni *et al.*, „The Role of Low-Level Laser Therapy in Bone Healing: Systematic Review”, *Int. J. Mol. Sci.*, t. 24, nr 8, s. 7094, kwi. 2023, doi: 10.3390/ijms24087094.
[21] A. H. Bekhet, B. Ragab, A. I. Abushouk, A. Elgebaly, i O. I. Ali, „Efficacy of low-level laser therapy in carpal tunnel syndrome management: a systematic review and meta-analysis”, *Lasers Med. Sci.*, t. 32, nr 6, s. 1439–1448, sie. 2017, doi: 10.1007/s10103-017-2234-6.
[22] S. Badıl Güloğlu, M. Bilgilisoy Filiz, K. K. Kılıç, Ş. Koldaş Doğan, İ. E. Toslak, i N. F. Toraman, „Treatment of carpal tunnel syndrome by low-level laser therapy versus corticosteroid injection: a randomized, prospective clinical study”, *Lasers Med. Sci.*, t. 37, nr 4, s. 2227–2237, cze. 2022, doi: 10.1007/s10103-021-03489-6.
[23] M. Nalbant, O. Ümit Yemişci, S. Özen, i Ş. Tezcan, „Ultrasonographic and electrophysiological outcomes of carpal tunnel syndrome treated with low-level laser therapy: A double-blind, prospective, randomized, sham-controlled study”, *Arch. Rheumatol.*, t. 37, nr 1, s. 19–30, mar. 2022, doi: 10.46497/ArchRheumatol.2022.8605.
[24] M. Smallcomb, S. Khandare, M. E. Vidt, i J. C. Simon, „Therapeutic Ultrasound and Shockwave Therapy for Tendinopathy: A Narrative Review”, *Am. J. Phys. Med. Rehabil.*, t. 101, nr 8, s. 801–807, sie. 2022, doi: 10.1097/PHM.0000000000001894.
[25] A. Posnakidis, D. Lytras, A. Kottaras, P. Iakovidis, I. Kottaras, i I. Chatziprodromidou, „The effect of laser and therapeutic ultrasound on the treatment of symptoms of carpal tunnel syndrome: A narrative review”, *Int. J. Orthop. Sci.*, t. 7, s. 451–454, maja 2021, doi: 10.22271/ortho.2021.v7.i2f.2663.
[26] A. Ahmad, F. Lazim, W. Syarafana, S. Mazni, S. Izani, i S. A. Bukry, „Effectiveness of Therapeutic Ultrasound for Treating Carpal Tunnel Syndrome in Women: A Systematic Review”, *Heal. Off. Res. Book Fac. Health Sci. UiTM*, t. 7, nr 1, s. 84–98, lis. 2024, Dostęp: 9 kwietnia 2026. [Online]. Dostępne na: https://healthscopefsk.com/index.php/research/article/view/366

[27] S. Chen *et al.*, „Effectiveness of therapeutic ultrasound for the treatment of carpal tunnel syndrome (the USTINCTS trial): study protocol for a three-arm, prospective, multicentre, randomised controlled trial”, *BMJ Open*, t. 12, nr 4, s. e057541, kwi. 2022, doi: 10.1136/bmjopen-2021-057541.
[28] N. Kumar, S. K. Chandan, D. Jalan, S. Sinha, B. Jaiswal, i D. K. Singh, „Ultrasound-guided interventions in primary carpal tunnel syndrome: perineural injection to thread carpal tunnel release”, *Br. J. Radiol.*, t. 96, nr 1150, s. 20230552, paź. 2023, doi: 10.1259/bjr.20230552.
[29] S. I. Kamel, B. Freid, C. Pomeranz, E. J. Halpern, i L. N. Nazarian, „Minimally Invasive Ultrasound-Guided Carpal Tunnel Release Improves Long-Term Clinical Outcomes in Carpal Tunnel Syndrome”, *AJR Am. J. Roentgenol.*, t. 217, nr 2, s. 460–468, sie. 2021, doi: 10.2214/AJR.20.24383.
[30] K. Shang, Y. Liu, i A. Qadeer, „Platelet-rich plasma in peripheral nerve injury repair: a comprehensive review of mechanisms, clinical applications, and therapeutic potential”, *Exp. Biol. Med.*, t. 250, s. 10746, 2025, doi: 10.3389/ebm.2025.10746.
[31] X.-Y. Dou i M. An, „Advances in the application of platelet-rich plasma in peripheral nerve injuries”, *Anesthesiol. Perioper. Sci.*, t. 3, kwi. 2025, doi: 10.1007/s44254-025-00100-x.
[32] J. Jiang, F. Xing, R. Luo, i M. Liu, „Effectiveness of Platelet-Rich Plasma for Patients With Carpal Tunnel Syndrome: A Systematic Review and meta-Analysis of Current Evidence in Randomized Controlled Trials”, *Front. Pharmacol.*, t. 13, s. 834213, 2022, doi: 10.3389/fphar.2022.834213.
[33] C.-Y. Lai *et al.*, „The Long-Term Analgesic Effectiveness of Platelet-Rich Plasma Injection for Carpal Tunnel Syndrome: A Cross-Sectional Cohort Study”, *Pain Med.*, t. 23, nr 7, s. 1249–1258, lip. 2022, doi: 10.1093/pm/pnac011.
[34] P. Hong *et al.*, „Efficacy and safety of platelet-rich plasma in the treatment of carpal tunnel syndrome: A network meta-analysis of different injection treatments”, *Front. Pharmacol.*, t. 13, s. 906075, 2022, doi: 10.3389/fphar.2022.906075.
[35] M.-A. Malahias, D. Chytas, A. F. Mavrogenis, V. S. Nikolaou, E. O. Johnson, i G. C. Babis, „Platelet-rich plasma injections for carpal tunnel syndrome: a systematic and comprehensive review”, *Eur. J. Orthop. Surg. Traumatol. Orthop. Traumatol.*, t. 29, nr 1, s. 1–8, sty. 2019, doi: 10.1007/s00590-018-2278-8.
[36] A. Seely, „The efficacy of extracorporeal shock wave therapy in comparison to low-level laser therapy for decreasing pain and symptom severity and increasing functional status in adult patients with carpal tunnel syndrome: a systematic review and meta-analysis”.
[37] F.-A. Yang *et al.*, „Injection therapy for carpal tunnel syndrome: A systematic review and network meta-analysis of randomized controlled trials”, *PLOS ONE*, t. 19, nr 5, s. e0303537, maja 2024, doi: 10.1371/journal.pone.0303537.