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COMPRESSION SYNDROMES OF THE UPPER EXTREMITIES: ENHANCED TREATMENT EFFICACY THROUGH ULTRASOUND THERAPY INTEGRATION

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Abstract: Compression syndromes of the upper extremities represent a heterogeneous group of peripheral neuropathies characterized by mechanical compression of nerve structures within confined anatomical spaces. These conditions have emerged as a predominant cause of occupational morbidity, constituting approximately 35-45% of all work-related peripheral nerve disorders in industrialized nations (Burton et al., 2016). The anatomical predisposition of certain nerve segments to compression, combined with repetitive mechanical stress and occupational demands, creates a perfect storm for the development of these debilitating conditions.

Key words: tunnel syndrome, upper extremities, therapeutic ultrasound, neurology.

Introduction. The most clinically significant compression syndromes affecting the upper extremities include carpal tunnel syndrome (CTS), affecting the median nerve at the wrist; cubital tunnel syndrome, involving ulnar nerve compression at the elbow; and radial tunnel syndrome, characterized by posterior interosseous nerve entrapment. Among these, carpal tunnel syndrome demonstrates the highest prevalence, with epidemiological studies reporting incidence rates ranging from 1.5 to 3.5 cases per 1000 population annually (Padua et al., 2016). Notably, gender disparities are pronounced, with women experiencing these conditions at rates 3-5 times higher than men, particularly in the 40-60 age demographic.

The pathophysiological cascade underlying these compression neuropathies involves a complex interplay of mechanical and ischemic factors. Initial nerve compression triggers localized edema formation, which subsequently increases intracompartmental pressure, creating a vicious cycle of progressive nerve dysfunction. This process results in segmental demyelination, impaired axoplasmic transport, and in severe cases, axonal degeneration with subsequent Wallerian degeneration distal to the compression site (Genova et al., 2020). The clinical manifestation progresses from initial sensory disturbances, including paresthesias and numbness, to motor weakness and eventual muscle atrophy if left untreated.

Contemporary diagnostic approaches rely heavily on clinical assessment complemented by electrophysiological studies, particularly nerve conduction studies and electromyography. While these methods provide valuable objective data regarding nerve function, they often fail to capture the full spectrum of patient symptomatology and may not correlate directly with functional impairment levels. Furthermore, traditional imaging modalities have limited utility in assessing nerve morphology and surrounding tissue changes.

Current therapeutic paradigms for compression syndromes primarily encompass conservative management strategies, including activity modification, splinting, anti-inflammatory medications, and corticosteroid injections. However, these conventional approaches often yield suboptimal outcomes, with significant recurrence rates and limited long-term efficacy (Piazzini et al., 2007). The inadequacy of traditional treatment modalities has prompted researchers to explore alternative therapeutic interventions that address both symptomatic relief and underlying pathophysiological mechanisms.

Therapeutic ultrasound has emerged as a promising adjunctive treatment modality for compression neuropathies, offering unique biophysical properties that may enhance nerve recovery. The proposed mechanisms of ultrasound therapy include thermal effects promoting increased blood flow and tissue metabolism, mechanical effects facilitating tissue mobilization and reducing adhesions, and potential neuroregenerative effects through acoustic stimulation (Ebenbichler et al., 2010). Recent systematic reviews and meta-analyses have suggested beneficial effects of ultrasound therapy in carpal tunnel syndrome, including improvements in pain scores, functional outcomes, and electrophysiological parameters.

Despite these encouraging findings, significant gaps remain in our understanding of optimal treatment protocols, patient selection criteria, and the precise mechanisms by which ultrasound therapy exerts its therapeutic effects. Additionally, most existing studies have focused exclusively on carpal tunnel syndrome, with limited investigation of ultrasound applications in other upper extremity compression syndromes.

The integration of ultrasound therapy with conventional treatment approaches represents a logical evolution in the management of compression neuropathies. This combined strategy aims to leverage the anti-inflammatory and analgesic effects of pharmacological interventions while simultaneously harnessing the unique biophysical properties of therapeutic ultrasound to promote nerve recovery and tissue healing.

Given the substantial socioeconomic burden of upper extremity compression syndromes, including direct healthcare costs, lost productivity, and reduced quality of life, there is an urgent need for more effective treatment strategies. The development of evidence-based, multimodal therapeutic approaches could significantly improve patient outcomes while reducing the need for surgical intervention and its associated risks and costs.

This investigation aims to address these critical knowledge gaps by systematically evaluating the therapeutic efficacy of combined pharmacological and ultrasound therapy in patients with upper extremity compression syndromes. Through comprehensive clinical, functional, and electrophysiological assessment, this study seeks to establish the added value of ultrasound therapy integration and provide evidence-based recommendations for optimized treatment protocols in this challenging patient population.

Research objective: to study and evaluate the diagnostic possibilities of clinical-neurological examination, electroneuromyography (ENMG) with subsequent ultrasound therapy in the complex treatment of upper extremity tunnel syndromes, aiming to increase the effectiveness of combined therapy and improve functional outcomes in patients.

Materials and methods. The study included patients with tunnel syndrome, with an average age of 34±5 years, totaling 47 people (main group). Women comprised 58.5% of the examined group, men correspondingly 41.5%. Patients had different spheres of activity: midwives (nurses in delivery rooms), obstetrician-gynecologists; bankers working mainly at computers; painters, installers; auto mechanics; i.e., patients were involved in intensive hand loading while performing professional and domestic activities. In 89% of cases, patients had disease signs on the right side, on the left side correspondingly 11%. The average disease duration was more than 12 months from initial symptoms. Disease comorbidity was noted in several patients in the form of chronic diseases: mainly overweight 27% (1st-2nd degree obesity); ENT pathology (sinusitis, frontal sinusitis) in 1.5%; arterial hypertension in two patients. From the main group of patients with tunnel syndrome, separate

subgroups were identified by lesion level: carpal-type tunnel syndrome was most common, 32%. Cubital-type tunnel syndrome was second in frequency, 28.8%. Syndromic disorders were noted as: carpal tunnel syndrome, peroneal, pronator syndrome, or combination of the presented syndromes. The research was conducted at the Multidisciplinary Clinic of SamSMU, Regional Hospital of Samarkand city, and the rehabilitation center of SamSMU during 2024-2025. All patients signed consent for the study. The healthy control group consisted of volunteers from among persons who applied to the MC SamSMU polyclinic for preventive examination, of identical age and gender, totaling 31 people. All participants without exception underwent clinical-neurological examination, additional diagnostic measures, standard (blood analysis, ECG, ENMG, hand vessel ultrasound with pain localization); separately, all patients in the main group underwent testing for diagnosis of disease specificity and type: Tinel's test, Phalen's test, tourniquet test. Pain syndrome during the study was recorded using the VAS scale. Additionally, the Boston Carpal Tunnel Syndrome Questionnaire (BCTSQ) was used. Statistical data processing was performed on a personal computer using statistical software with mean and standard deviation. To assess the significance of parameter differences between some parameters in patient groups, the Mann-Whitney U-test was used. The significance criterion for differences (p) was taken as <0.05.

Results. All patients in the main group at the time of application to the polyclinic and hospitalization had identical complaints: pain in hands with irradiation to fingers (1st, 2nd, 3rd, and 4th), difficulty in motor activity in hands. At the same time, painful sensations most often intensified during sleep or pain symptoms intensified with load (considering that predominantly disease signs were localized in the working hand). With objective control of sensory disturbance, signs of hypoesthesia were noted, totally over the entire hand surface in 79% of cases; in other cases, changes in tactile sensitivity were not noted. During neurological examination, in 95% of cases, weakness and motor function disturbances in hand muscles, numbness sensation in fingers were discovered. Tinel's test indicators (tapping causes tingling and pain) in the examined main group was positive only in 27%, this in 13 patients. While Phalen's test (hand flexion for 1 minute) was positive in 21 patients, which constituted 44.6%, with hand pain signs noted on average at 30 seconds. Boston questionnaire coefficient data showed the following results: symptom severity (SSS) averaged 3 points; functional impairment (FSS) averaged 5 points, indicating significant deviations in nerve impulse conduction. 39% of patients experienced pain under temperature fluctuation effects (high or low). 66% of patients complained of pain (like electric shock) when pressing with a finger in the numbness zone. Continuous pain character was complained of by patients in smaller numbers: 19.1%. Even less frequently, attack-type pains were noted: 12%. In 33% of cases, patients indicated pain irradiation to the proximal zone. Standard pain presentation on the VAS scale revealed an average score of 6 points in most cases. The tourniquet test is considered not indicative for tunnel syndromes when considered separately; however, in the examination complex it is necessary, as a rule, a positive test result confirms the presence of compression. Autonomic signs of changes were expressed in the following symptoms: temperature change (either cold or hot hand), skin pallor, marbled color (only in 2 patients). A significant fact is the expression level of pain syndrome depending on disease type: patients with carpal-type tunnel syndrome had moderate character, while with cubital-type tunnel syndrome, pain character was strongly expressed, which statistically $P<0.005$ proves the predominance of clinical-neurological symptoms of cubital-type tunnel syndromes. The same difference was noted when controlling the comparison of numbness between these two disease types, where statistically significant $P<0.005$. Electromyography is considered the gold standard in studying tunnel syndromes: in main group patients, ENMG changes were revealed: sensory conduction velocity was weakened in the hand in all patients, while sensory conduction velocity indicators averaged 35±7 m/s; distal M-response latency was expanded in patients (86%), where the parameter value averaged 5.5±0.9 ms, and M-response amplitude was 7.3±2.9 mV, corresponding to normative indicators. However, sensory M-response in 40% of cases was noted below 11 μV, indicating low amplitude. Median nerve indicators were characteristic, showing pronounced conductivity decrease to 32±6 ms (normally should be more than 52 m/s). Ultrasound analysis results of main group patients characterized median nerve cross-sectional area increase to 22 sq.mm in 70% of cases and clear change in the form of thickening to 21 sq.mm at

the carpal tunnel entrance in 28% of patients. Additionally, median nerve doubling at the wrist was revealed, which most likely has anatomical peculiarities, in 3 patients. The goal of conservative treatment of tunnel syndrome with mild and moderate lesion levels is nerve trunk decompression and restoration of its functions. In this regard, the following therapy methods were proposed to main group patients: 1) all patients without exception needed to use splints for hand fixation and pressure traumatization reduction; 2) main group patients were divided into two subgroups under equal and identical conditions, where subgroup A (23) received medication therapy - Dicloberl 3ml i.m. for 5 days, transitioning to oral regimen Dicloberl retard 1 capsule once daily for another 5 days; subgroup B (24) received medication therapy (Dicloberl i.m. for 5 days 3ml) and physiotherapy in the form of therapeutic ultrasound, a method that produces acoustic high-frequency vibrations with thermal effects. According to literature data (Ebenbichler G.R. et al., 2010), pulsed therapeutic ultrasound over the carpal tunnel level for 15 minutes in 20 sessions relieves pain and paresthesia symptoms while simultaneously improving median nerve conduction and strength. Patient re-examination was conducted depending on the proposed treatment: in subgroup A after 2 weeks, in subgroup B after 25 days. In subgroup A patients who received traditional Dicloberl treatment, before treatment, as presented above, hypoesthesia signs were of mild and moderate severity; after treatment, the overall hypoesthesia condition remained the same, values decreased in individual zones (upper and lower), however, statistically significant differences were not achieved before and after therapy for any nerve type, where $P<0.5$. Motor disturbances in the form of muscle weakness, partial hypotrophy were present in most patients (77%) before treatment; after treatment, Tinel's test in subgroup A patients did not reveal dynamic changes; additionally, in 16% of cases, complaint intensification was revealed, which when comparing indicators does not provide statistical signs of reliability. The same picture is noted when conducting Phalen's test after completion of medication treatment; statistically significant differences were not found. When conducting the tourniquet test, pain intensification to intensive limits was noted in at least 30% of patients before therapy initiation; pain syndrome indicators decreased in patients (12.9%), indicating a positive effect but not indicating statistically significant differences before and after treatment. According to ENMG data, M-response amplitude level (especially thumb) equaled (before treatment 4.5±1.5 mV), and after recommended therapy had practically no changes 4.49±1.4 mV. The median nerve before treatment was 3.5±1.5 ms, subsequently did not differ statistically significantly after treatment ($p<0.5$). Sensory response level of median and ulnar nerves in subgroup A with medication treatment before treatment averaged 8.2±3.3 μV; after two weeks, it was 9.3±3.3 μV, respectively, we observe the absence of statistically significant differences before and after treatment. The value (on average) of excitation propagation speed through sensory fibers of the median nerve against Dicloberl therapy before treatment was 42±7.9 m/s, after treatment up to 42±8.1 m/s; statistically significant confirmation of obtained results was not revealed. Thus, when comparing clinical, instrumental data, testing of tunnel syndrome scales (by individual nerve types: median and ulnar nerves) receiving nonsteroidal drug therapy, statistically significant differences were not revealed, except for pain syndrome reduction in 58% of cases.

Results of treatment with Dicloberl followed by therapeutic ultrasound sessions in subgroup B revealed positive dynamics with statistically significant hypoesthesia reduction, confirmed by $P<0.005$ value. Before treatment initiation, more than 55% of patients had abnormal reaction to sensory stimuli (e.g., painful pressure); after proposed therapy, only 11% complained of pain irritation, namely patients who had median nerve disorders.

It should be noted that pain symptom to temperature stimulus was registered before treatment in at least 30% of patients; after treatment in subgroup B combined therapy, all patients in this subgroup had no pain symptom to temperature stimulus, which was reflected as statistically significant level $P<0.005$.

Positive dynamics were noted when conducting Tinel's test, in the form of reduction and shortening of score range to 1.0 on average. When conducting Phalen's tests, positive dynamics were also noted, where the score indicator reliably reflects the effectiveness of research results. When conducting the

tourniquet test, the highest degree of effectiveness of the proposed combined therapy was noted; positive dynamics showed statistically significant improvement with P<0.005 value.

Neurophysiological indicators on ENMG, in the form of average motor response amplitude value in studied median and ulnar nerves before treatment were within 4.5±1.5 mV values (in this subgroup), while after conducted combined treatment, significant positive M-response dynamics were noted. The character of segmental demyelination of motor branch of median and ulnar nerves in the carpal canal before therapy initiation corresponded to the following value: 3.3±1.5 ms; after therapy combining two directions, statistically significant improvement is noted.

Sensory portion of median and ulnar nerves before treatment initiation, average amplitude value of action potential was below normal and constituted 8.7±3.9 μV; against recommended therapy, in this subgroup statistically significant confirmation of positive indicators was revealed, P<0.01. That is, it should be noted that average excitation propagation speed through sensory fibers of studied nerves, in confirmation of clinical-neurological symptoms (expressed in painful sensations), before treatment was reduced to 40±7 m/s. After combined therapy, significant condition improvement was discovered, with sensory signal increase to 47±7.5 m/s, where P<0.005. Thus, the research result showed statistically significant improvement of clinical, instrumental, and test indicators against the use of combined therapy Dicloberl and therapeutic ultrasound, despite the sufficiently shortened treatment course and rapid effectiveness assessment of proposed treatment.

Conclusions. The study was dominated by patients with acute and chronic forms of nerve compression; the majority of patients during examination revealed moderate and severe pain syndrome; muscle weakness and amyotrophy; sensory numbness sensation throughout the entire hand, intensifying during sleep in carpal tunnel syndrome; positive tests of temperature and mechanical impact; nerve numbness in cubital tunnel syndrome. The use of such diagnostic methods as Tinel's tests, Phalen's, tourniquet test; instrumental diagnostics ENMG and diagnostic ultrasound are the main directions for correct diagnosis of tunnel syndromes; additionally, these diagnostic methods are criteria for dynamic effectiveness of subsequent treatment of patients with tunnel syndrome. Recommended treatment with Dicloberl and therapeutic ultrasound combines traditional treatment methods with a complex of analgesic, anti-inflammatory effect and nerve conduction improvement; this is indicated by positive dynamics in clinical-neurological, instrumental, and test indicators in patients with tunnel syndrome.

List of literature:

1. Abdulov A.S., Petrenko N.V., Ismailov A.M. Modern methods of diagnosis and treatment of tunnel syndromes of the upper extremities // Neurological Journal, 2023, No. 3, pp. 45-52.
2. Barinov A.N., Strokov I.A. Tunnel syndromes: clinic, diagnosis, treatment. Moscow: GEOTAR-Media, 2022. 368 p.
3. Dzhurabekova A.T., Khasanov A.Y. Application of ultrasound therapy in the treatment of compression neuropathies // Issues of balneology, physiotherapy and therapeutic physical education. - 2024. – No. 2. – pp. 28-34
4. Zhivolupov S.A., Samartsev I.N. Neurophysiological diagnostics of diseases of the peripheral nervous system. – St. Petersburg: SpecLit, 2021. – 506 p.
5. Aboonq M.S. Pathophysiology of carpal tunnel syndrome // Neurosciences. – 2015. – Vol. 20(1). – P. 4-9.
6. Baeza-Barragán A.R., Garay-Mendoza D., Hernández-González M.A. Ultrasound therapy for carpal tunnel syndrome: systematic review // Rehabilitacion (Madr). – 2023. – Vol. 57(2). – P. 100-112.
7. Burton C.L., Chen Y., Chesterton L.S., van der Windt D.A. Clinical course and prognostic factors in conservatively managed carpal tunnel syndrome: a systematic review // Archives of Physical Medicine and Rehabilitation. – 2016. – Vol. 97(5). – P. 836-852.

8. Ebenbichler G.R., Resch K.L., Nicolakis P., et al. Ultrasound treatment for treating the carpal tunnel syndrome: randomised "sham" controlled trial // BMJ. – 2010. – Vol. 316(7133). – P. 731-735.
9. Genova A., Dix O., Saefan A., Thakur M., Hassan A. Carpal tunnel syndrome: a review of literature // Cureus. – 2020. – Vol. 12(3). – e7333.
10. Han Carlson R., Jones N.F. Peripheral nerve entrapment and compression neuropathies. – Los Angeles: Hand Surgery Associates, 2010. – 456 p.
11. Ibrahim I., Khan W.S., Goddard N., Smitham P. Carpal tunnel syndrome: a review of the recent literature // Open Orthopaedics Journal. – 2012. – Vol. 6. – P. 69-76.
12. Lee H.J., Kim I., Hong J.T. Early surgical treatment of cubital tunnel syndrome: outcomes in patients with mild to moderate disease // Journal of Plastic Surgery and Hand Surgery. – 2018. – Vol. 52(5). – P. 293-297.
13. Padua L., Coraci D., Erra C., et al. Carpal tunnel syndrome: clinical features, diagnosis, and management // The Lancet Neurology. – 2016. – Vol. 15(12). – P. 1273-1284.
14. Piazzini D.B., Aprile I., Ferrara P.E., et al. A systematic review of conservative treatment of carpal tunnel syndrome // Clinical Rehabilitation. – 2007. – Vol. 21(4). – P. 299-314.
15. Wu Y.T., Ho T.Y., Chou Y.C., et al. Six-month efficacy of platelet-rich plasma for carpal tunnel syndrome: A prospective randomized, single-blind controlled trial // Scientific Reports. – 2017. – Vol. 7(1). – P. 94-105.