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Tunnel Syndrome of the Upper Extremities: Possibilities of Combined Treatment with the Use of Therapeutic Ultrasound

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Abstract Tunnel syndromes of the upper extremities represent a group of compression-ischemic neuropathies arising from compression of peripheral nerves in anatomically narrow spaces. This pathology occupies a leading place among occupational diseases and accounts for up to 30-40% of all cases of peripheral nervous system damage in working-age individuals. The most common forms are carpal tunnel syndrome (median nerve compression), cubital tunnel syndrome (ulnar nerve compression), and Guyon's canal syndrome. According to epidemiological studies, the incidence of carpal tunnel syndrome is 1-3 cases per 1000 population per year, with women being affected 3-5 times more often than men.

Keywords Tunnel syndrome, Upper extremities, Therapeutic ultrasound, Neurology

1. Introduction

The latest statistical data from international standards for 2022-2025 noted that the most frequent patient complaints were related to peripheral nervous system diseases, and in the structure of tunnel neuropathies, the percentage of referrals exceeds 46%, with more than 83% of these problems affecting the upper extremities [1,3]. Disease factors are identified as complex effects of external and internal conditions leading to nerve compression in the tunnel [10,12]. The main criterion in the pathomechanism of the disease, acute and chronic traumatization of tunnel syndrome, is edema, which leads to local demyelination, disruption of axonal transport, and Wallerian degeneration of nerve axons distal to the compression site [2,4]. Clinical-neurological demonstration of signs at disease onset presents as painful sensations: hypoesthesia, paresthesia in the hand and fingers area. The disease successfully progresses to chronic form, where weakness and atrophy of innervated muscles join the described symptoms [5,7]. Diagnosis of upper extremity tunnel syndromes is based on clinical-anamnestic indicators; pain sensation testing, instrumental methods such as ENMG, vascular ultrasound. Clinical and neurophysiological methods of recent years are beyond doubt; however, aspects commonly accepted in practical healthcare do not provide a complete picture of the disease development mechanism, and proposed conservative treatment methods lead to symptom recurrence [9,11]. All this serves as grounds for further development and improvement of diagnostic and treatment methodology [6,8].

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.

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2. 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.

3. 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.

4. Conclusions

According to literature review data from foreign and domestic sources, it should be noted that tunnel syndromes are quite widespread in the last decade, mainly among people having professional load on the radiocarpal zone (working hand) and females; additionally, patients apply to polyclinics and hospitals later than disease debut, using home treatment methods. 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.

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