DIGEST AND REVIEWS

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Effectiveness of extracorporeal shock wave therapy during the treatment of patients with orthopedic and traumatological upper limbs diseases (literature review)

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This method of conservative treatment of orthopedic and traumatological conditions diseases, such as extracorporeal shock wave therapy (ESWT) has been gaining popularity in recent years. Objective. Review modern (for the last 5 years) sources of literature on the use of ESWT in the treatment of ortopedo-traumatic diseases of the upper limbs. Methods. Publications from the search system Google, PubMed, Medline and other relevant sources scientific and medical information with the indication of the subject method and the most common orthopedic and traumatological of diseases of the upper limb were analyzed: «ESWT (Extracorporeal Shockwave Therapy) AND fracture», «ESWT AND tendonitis», «ESWT AND subacromial impingement syndrome», «ESWT AND adhesive capsulitis», «ESWT AND frozen schoulder», «ESWT AND trigger finger», «ESWT OR AND lateral epicondylitis», «ESWT AND medial epicondylitis», «ESWT AND ostheoarthritis», «ESWT AND tendinopathy», «ESWT AND injure». Results. A total of 272 scientific articles were found. The articles related to histological, biomechanical and experimental studies, wounds, burns and post-stroke changes of the upper limbs, diseases other localizations, as well as methods of conservative and surgical treatment were excluded. 51 articles were selected for analysis. It was determined that ESWT is used in the treatment of lateral epicondylitis; calcifying tendinitis of muscles shoulder tendinopathies, partial injuries of rotator cuff muscles of the shoulder; subacromial impingement syndrome; adhesive capsulitis of the shoulder; ununited fractures and delayed union; navicular bone of the wrist; diseases of the hand (carpal tunnel syndrome, snapping finger, Dupuytren's contracture, tendinopathies); fractures of the humerus and clavicle; tendinopathy of the distal tendon of the biceps brachii muscle. Conclusions. ESWT is a modern and effective method of conservative treatment of orthopedic and traumatological diseases of the upper limb and can be used both independently and in combination with standard methods of conservative treatment. Key words. Shock wave therapy, orthopedic and traumatological diseases of the upper extremities, conservative treatment, tendinitis, tendinopathy, fracture.

Останніми роками набуває популярності такий метод консервативного лікування ортопедо-травматологічних захворювань, як екстракорпоральна ударно-хвильова терапія (ЕУХТ). Мета. Огляд сучасних (за останні 5 років) джерел літератури щодо використання ЕУХТ під час лікування ортопедо-травматологічних захворювань верхньої кінцівки. Методи. Проаналізовано публікації з пошукової системи Google, баз PubMed, Medline та інших релевантних джерел науково-медичної інформації з вказанням досліджуваного методу та найпоширеніших ортопедо-травматологічних захворювань верхньої кінцівки: «ESWT (Extracorporeal Shockwave Therapy) AND fracture», «ESWT AND tendonitis», «ESWT AND subacromial impingement syndrome», «ESWT AND adhesive capsulitis», «ESWT AND frozen schoulder», «ESWT AND trigger finger», «ESWT OR AND lateral epicondylitis», «ESWT AND medial epicondylitis», «ESWT AND ostheoarthritis», «ESWT AND tendinopathy», «ESWT AND injure». Результати. Загалом знайдено 272 наукові статті. Із пошуку виключено роботи, які стосуються гістологічних, біомеханічних та експериментальних досліджень, ран, опіків і післяінсультних змін верхніх кінцівок, захворювань інших локалізацій, а також методик консервативного та хірургічного лікування. Відібрано для аналізу 51 статтю. Визначено, що ЕУХТ використовують у лікуванні латерального епікондиліту; кальцифікуючого тендиніту м'язів плеча; тендинопатій, часткових ушкоджень м'язів обертачів плеча; субакроміального імпінджмент синдрому; адгезивного капсуліту плеча; незрощених переломів і таких, які повільно зростаються; човноподібної кістки зап'ястка; захворювань кисті (синдрому карпального каналу, клацаючого пальця, контрактури Дюпюїтрена, тендинопатій); переломів плечової кістки та ключиці; тендинопатії дистального сухожилка двоголового м'яза плеча. Висновки. ЕУХТ є сучасним та ефективним методом консервативного лікування ортопедо-травматологічних захворювань верхньої кінцівки і може бути використаним як самостійно, так і в комбінації зі стандартними способами консервативного лікування. Ключові слова. Ударно-хвильова терапія, ортопедо-травматологічні захворювання верхніх кінцівок, консервативне лікування, тендиніт, тендинопатія, перелом.

Key words. Shock wave therapy, orthopedic and traumatological diseases of the upper extremities, conservative treatment, tendinitis, tendinopathy, fracture

Introduction

The most common causes of upper extremity pain are lateral and medial epicondylitis, rotator cuff tendinopathy, and subacromial impingement [1–5].

Extracorporeal shock wave therapy (ESWT) is a conservative physiotherapeutic method of treatment that was first employed in the 1980s to treat urolithiasis [1–5]. Sunsequently, the ESWT method developed and began to be used in orthopedics and traumatology (with such main areas as tendinopathy of the upper and lower extremities, non-fused fractures, etc.) [2, 3]. For the first time, the ESWT method was used to treat plantar fasciitis in 1996 [1–3]. S. Defoot et al. [6] reported that in the same year, J. D. Rompe described the ESWT method in the case of lateral epicondylitis. As for the upper extremities, the first studies of the technique were published in relation to the treatment of lateral epicondylitis and tendinopathy of the shoulder rotator muscles [1, 3, 4].

The main influential therapeutic factors of ESWT are the stimulation of angiogenesis and the production of vascular and osteogenic growth factors [1–3]. Also, some authors cite the effect of high-energy ESWT on the destruction of calcium deposits, both as a result of mechanical impact and as a result of the inflammatory response and phagocytosis of calcifications [2, 3, 7]. Many orthopedic traumatologists use the ESWT method in the treatment of orthopedic diseases of the upper extremities, but the debate about its feasibility continues.

Purpose: to review modern (over the last 5 years) sources of literature on the use of extracorporeal shock wave therapy in the treatment of orthopedic and traumatological diseases of the upper extremities.

Material and methods

Publications from the Google search engine, scientific and metric electronic databases PubMed, Medline and other relevant sources of scientific and medical information were analyzed.

The literature review was carried out using search queries indicating the researched method and the most common orthopedic and traumatological diseases of the upper limb, namely: «ESWT (Extracorporeal Shockwave Therapy) AND fracture», «ESWT AND tendonitis», «ESWT AND subacromial impingement syndrome», «ESWT AND adhesive capsulitis», «ESWT AND frozen shoulder», «ESWT AND trigger finger», «ESWT OR AND lateral epicondylitis», «ESWT AND medial epicondylitis», «ESWT AND ostheoarthritis», «ESWT AND tendinopathy», «ESWT AND injury».

Results and their discussion

In total, 272 scientific articles were found by the above search queries. Studies related to histological, biomechanical and experimental research, wounds, burns and post-stroke changes of the upper limbs, diseases of other localizations (lower limbs, spine, etc.), as well as other methods of conservative and surgical treatment were excluded from the results of the study.

51 articles on the treatment of orthopedic and traumatological diseases of the upper extremities using the ESWT method were selected for evaluation (Fig. 1).

The diagram shows that the ESWT method is used in the case of lateral epicondylitis — 13 articles [6, 8–19], calcifying tendinitis of the shoulder muscles — 13 [7, 20–31], tendinopathy, shoulder muscle injuries, and subacromial impingement syndrome — 7 [17, 32–37] (1 article [17] dealt with the study of shoulder tendinopathy and lateral epicondylitis, therefore it is included in both groups), hand diseases (carpal tunnel syndrome, snapping finger, and tendinopathy) — 4 [41–44], fractures of the navicular bone of the wrist (non-fused and slowly healing) — 4 [45–48], adhesive capsulitis of the shoulder — 3 [38, 40]; fractures of the humerus and clavicle — 2 [49, 50]; biceps tendinopathy — 1 [51].

All articles covered literature reviews, randomized clinical trials (RCTs), retrospective studies (RSs), meta-analyses and case-control studies (Table). Articles (5), which considered the properties of ESWT and gave a general overview of diseases of the upper and lower extremities, were excluded from the assessment.

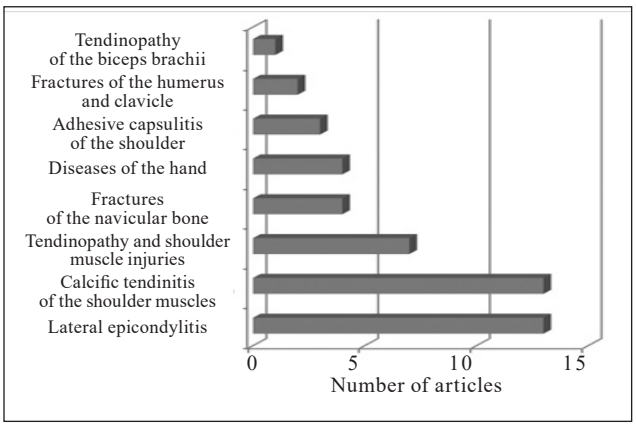

Fig. 1. Distribution of orthopedic and traumatological diseases of the upper extremities, treated by ESWT method

In the selected materials, the largest number of randomized clinical trials was presented in 20, retrospective in 11, literature reviews in 8, meta-analyses in 4, case-control studies in 2. Randomized controlled studies on the use of ESWT were distributed as follows: lateral epicondylitis in 10, shoulder joint disorders in 8 (calcifying tendinitis, tendinopathies, partial injuries of the rotator cuff of the shoulder, adhesive capsulitis), snapping finger in 1, non-union of the navicular bone in 2. In 3 meta-analyses, the results of ESWT in the case of lateral epicondylitis were highlighted, calcifying tendinitis of the shoulder in 1.

Lateral epicondylitis of the shoulder is the result of chronic inflammatory degeneration of the tendons of the forearm extensors at the point of attachment to the lateral epicondyle of the humerus, with a prevalence of 1–3% of the general population [2, 3, 8, 9]. In many articles, the ESWT method for the treatment of lateral epicondylitis was compared with other conservative methods [8–10].

C. Yan et al. [8] performed a meta-analysis comparing the results of treatment of epicondylitis with ultrasound (US) (115 patients) and ESWT (118). ESWT was shown to be more effective than US. The same result was published by B. Yalvas et al. [14], who included in the study 20 people in whom US was used with ESWT in 24, and D. Stasinopoulos [9] (US — 63 patients, ESWT – 117).

T. Turgay et al. [10] performed an RCS to compare ESWT with low-level laser therapy (26 patients in each group). The results of ESWT turned out to be better. In another RCS, the use of ESWT (14 patients) with ultrasound and kinesiotaping (13) was analyzed. According to sonographic studies, ESWT is more effective [11], and compared to kinesiotaping, it is less effective [12]. The therapeutic effect of ESWT was better in combination with nutritional support [17].

ESWT (17 patients) was equally effective compared to acupuncture (17) [13]. Also, the same effectiveness of ESWT was established with surgical treatment [6], photobiomodulation [19] and in combination with stretching exercises [18].

In meta-analyses, which included articles on the treatment of lateral epicondylitis using ESWT until July 2019, conflicting results were obtained. In particular, S. Yoon et al. [15] (reviewed samples of 578 patients in the comparison group who did not receive additional treatment, 588 in the ESWT group) did not find differences in pain reduction according to the VAS scale and grip strength. On the contrary, G. Yao et al. [16] (534 subjects in the comparison group, 501 — ESWT) concluded that ESWT can effectively and safely relieve pain and functional disorders. Both groups of authors believe that it was necessary to perform high-quality RCSs to prove better functional results of treatment of lateral epicondylitis with ESWT and to develop appropriate protocols.

Diseases of the shoulder joint (calcifying and non-calcifying tendinitis, tendinopathy, partial rotator cuff damage)

In calcifying tendinitis, calcium deposits accumulate in the tendons of the shoulder muscles and the subacromial space [7, 20–25]. Non-calcifying tendinitis of the shoulder is also a fairly common disorder, which clinically presents with similar symptoms [26–32]. Damage to the rotator cuff of the shoulder is detected in 2–3.8 % of the general population [33–37]. Many methods of conservative and surgical treatment of these diseases were proposed, with the goal to reduce inflammation, restore the functions of the abnormally changed tendon, and prevent recurrence [2, 3, 5, 10].

J. Bechay et al. [21], comparing the use of conservative (needle lavage of calcifications, ESWT) and surgical treatments, proved the same effectiveness of both methods; surgical intervention was usually used in conditions of inefficiency of conservative treatment. For the treatment of calcifying tendinitis of the shoulder, needle lavage of calcifications using ultrasound control in combination with subacromial injection of corticosteroids was more effective than ESWT [22, 23, 25]. In a retrospective study, K. Wu et al. [7] determined that the ESWT method was more effective for non-calcifying and initial stages of calcifying tendinitis.

A. Frizziero et al. [24] found that for the treatment of tendinopathy of the shoulder rotator muscles, the ESWT procedure was equally effective with intra-articular injection of hyaluronic acid, although the rate of achieving the analgesic effect was higher in the latter group.

A retrospective cohort analysis based on one center (67 patients) determined that the use of radial ESWT according to an individual protocol (depending on the response to manipulation) made it possible to obtain a long-term result of improvement (within a year) in 92 % of cases. The success of using the technique was assessed by reducing pain by more than 60 % according to VAS [28]. The inclusion of eccentric exercises in the ESWT procedure did not affect its effectiveness [26].

Some authors studied the combination of focal and radial ESWT. In particular, M. Abo Al-Khair et al. [27] recorded a better clinical, functional and sonographic result in the case of treatment of calcific tendinitis of the shoulder with the use of combined focal and radial shock waves.

Table

Results of studies of the ESWT method in selected articles

Author, year of publication	Type of study	Number of patients	Method of comparison	ESWT effectiveness
1	2	3	4	5
Lateral epicondylitis				
Yan C., 2019 [8]	meta-analysis	233	ultrasound	more effective
Stasinopoulos D., 2018 [9]	RCS	180	ultrasound	more effective
Turgay T., 2020 [10]	RCS	52	low-level laser therapy	more effective
Ozmen T., 2021 [11]	RCS	27	ultrasound, kinesiotaping	more effective than ultrasound
Guler T., 2020 [12]	RCS	40	kinesiotaping	less effective
Wong C., 2016 [13]	RCS	34	acupuncture	equally effective
Yalvac B., 2018 [14]	RCS	44	ultrasound	more effective
Yoon S.Y., 2020 [15]	meta-analysis	1166	other conservative methods of treatment	more effective
Yao G., 2020 [16]	meta-analysis	1035	other conservative methods of treatment	more effective
Vitali M., 2019 [17]	RCS	30	nutritional support (Tendisulfur forte)	more effective together with nutritional support
Defoort S., 2021 [6]	RCS	29	surgical treatment	equally effective
Aydin C., 2017 [18]	RCS	46	ESWT in combination with stretching exercises	equally effective
Celik D., 2019 [19]	RCS	43	photobiomodulation	equally effective
Calcific tendinitis of the shoulder				
Pakos E., 2018 [20]	RS	66	—	effective in combination with calcification lavage
Bechay J., 2020 [21]	literature review	—	surgical treatment	equally effective
Louwerens J., 2020 [22]	literature review	—	needle lavage of calcifications under US control	less effective
Wu K., 2019 [7]	a retrospective comparative study	40	—	more effective in non-calcifying and initial stages of calcific tendinitis
Arirachakaran A., 2016 [23]	meta-analysis	1204	needle lavage of calcifications under US control, intra-articular corticosteroids and combined treatment	more effective needle lavage of calcifications under US control
Del Castillo-Gonzalez F., 2016 [25]	RCS	201	needle lavage of calcifications under US control	more effective needle lavage of calcifications under US control
Carlisi E., 2018 [26]	RS	22	eccentric exercises	inclusion of eccentric exercises does not affect the effectiveness of ESWT
Abo Al-Khair M., 2021 [27]	RCS	30	focal, radial and a combination of both ESWT methods	a more effective combination of both methods
Malliaropoulos N., 2017 [28]	RS	67	—	more effective
Chou W., 2017 [29]	RS	241	—	ineffective in the presence of unfavorable factors
Louwerens J., 2016 [30]	literature review	22 studies (1258 of shoulder joints)	needle lavage of calcifications under US control, arthroscopic treatment	equally effective

Continuation of Table

1	2	3	4	5
Lanza E., 2021 [31]	RCS	70	the effect of previously conducted ESWT on the result of treatment with needle lavage of calcifications under US control	does not affect the outcome of treatment
Shoulder tendinopathy				
Frizziero A., 2017 [24]	RCS	34	intra-articular injection of hyaluronic acid	equally effective
Castro B., 2021 [32]	literature review	5 RCSs are included	NSAIDs, laser therapy	efficiency has been confirmed in the short-term period of up to 3 months
Klüter T., 2018 [35]	RCS	86	ESWT method was supplemented with electromagnetic therapy	efficiency is higher in the group of combination with electromagnetic therapy
Tendinitis of the shoulder and partial injuries of the rotator cuff of the shoulder				
Chou W., 2018 [33]	RS	36	—	equal efficiency has been confirmed
Calcific tendinitis, adhesive capsulitis, tendinopathy and partial rotator cuff injuries of the shoulder				
Oliveira V., 2021 [34]	RCS	54	—	equal efficiency has been confirmed
Subacromial impingement syndrome				
Santamato A., 2018 [36]	RCS	30	ESWT method was supplemented with isokinetic exercises	efficiency is higher in the group of combination with isokinetic exercises
Partial damage to the shoulder rotator muscles				
Petrofsky J., 2020 [37]	«case – control»	1	—	efficiency has been confirmed
Adhesive capsulitis of the shoulder				
Redler L., 2019 [38]	literature review	—	ESWT method was compared with other conservative and surgical treatment methods	efficiency has been confirmed
Cao D., 2019 [39]	literature review	—	—	efficiency has been confirmed
Qiao H., 2020 [40]	RCS	30	oral prednisolone	more effective
Carpal tunnel syndrome				
Ambroziak M., 2020 [41]	literature review	—	—	efficiency has not been proven due to a small number of studies
Clicking finger				
Chen Y., 2021 [42]	RCS	60	—	more effective
Clicking finger, Dupuytren's contracture				
Ferrara P., 2020 [43]	literature review	—	—	efficiency has been confirmed
Aykut S., 2018 [44]	RS	23	—	efficiency has been confirmed at an early stage of treatment
Non-union of the navicular bone				
Muhldorfer-Fodor M., 2020 [45]	RCS	68	—	efficiency has been confirmed in the long term
Schleusser S., 2020 [46]	RS	20	—	increased capillary blood flow
Fallnhauser T., 2020 [47]	RS	42	—	efficiency has been confirmed
Quadlbauer S., 2019 [48]	RCS	42	—	efficiency has been confirmed

Continuation of Table

1	2	3	4	5
Non-union and slowly healing fractures of the humerus				
Dahm F., 2021 [49]	RS	236	—	efficiency has been confirmed
Non-union fractures of the clavicle				
Yue L., 2021 [50]	«case – control»	1	—	efficiency has been confirmed
Chronic tendinopathy of the distal tendon of the biceps brachii muscle				
Furia J., 2017 [51]	RS	48	—	efficiency has been confirmed

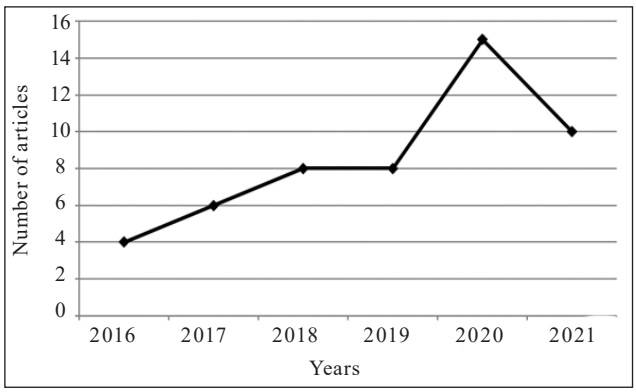

Fig. 2. Distribution of studies by year of publication

However, during the treatment of calcifying tendinitis, it is necessary to take into account unfavorable factors (the size of the calcifications exceeding 15 mm and the duration of the disease over 11 months), which make ESWT ineffective [29]. In calcifying tendinopathy of the shoulder, it was possible to achieve good or excellent clinical results after ESWT procedures, needle lavage of calcifications under ultrasound control and arthroscopy. Side effects and complications after treatment should be taken into account when making a decision for each patient [30]. The ESWT procedure performed before needle lavage of calcifications under ultrasound control did not affect the final result of treatment [31].

B. Castro et al. [32] conducted a systematic review that included 5 RCSs where the effectiveness of ESWT was proven in the short term (up to 3 months). The authors noted absence of studies on the results of using the technique in the medium and long-term periods. In groups of patients with high and usual physical activity, no difference in the effect of ESWT on the outcome of treatment of tendinitis of the shoulder and partial damage of the rotator cuff muscles was found in a retrospective study [33]. The same effectiveness and safety of the technique in the treatment of patients with adhesive capsulitis, tendinopathy, calcifying tendinitis and partial injuries of the shoulder rotator muscles have also been established [34, 37]. Complex application of ESWT with electromagnetic therapy made it possible to obtain a more pronounced reduction of pain and improvement of shoulder function than in the control group without ESWT [35]. Supplementation of ESWT with isokinetic exercises improved treatment outcomes [36].

Adhesive capsulitis affects the synovial membrane of the shoulder joint and its capsule. Inflammation begins, resulting in the so-called adhesion (individual particles of the capsule). It triggers development of adhesions, subsequently becoming scars. The abnormal process causes severe pain and limitation of joint function, with possible complete immobility. Due to this, the disease is called «frozen shoulder syndrome». This abnormality is diagnosed in 2–5 % of the adult population of the planet. It is mostly observed after 35 years, more often in women [38, 40].

ESWT is also used for the treatment of adhesive capsulitis, its effectiveness has been confirmed [38, 39]. In the conducted RCSs, a better result was established after the use of ESWT compared to oral prednisolone [40].

Diseases of the hand. In ESWT treatment of carpal tunnel syndrome in the postoperative period, its effectiveness has not been determined due to a small number of studies [41]. In trigger finger, high-energy ESWT had a higher effectiveness [42].

In a systematic review of the literature P. Ferrara et al. [43] proved the effectiveness and safety of ESWT in the treatment of Dupuytren's disease and clicking finger. It has been shown that the procedure is appropriate at the early stage of contracture as an alternative to injection and surgical methods of treatment [44].

Intraoperative ESWT was used during surgical correction of non-union of the navicular bone with a free allograft and better results were found after 12 months than in the control (without ESWT) [45]. According to S. Schleusser et al. [46] in 20 volunteers, capillary blood flow in the navicular bone, which is one of the factors of osteogenesis, increased within

30 minutes after the procedure. In 71 % of patients after ESWT, consolidation was clinically determined (average duration 8.4 months) in the case of non-fused, slow-growing navicular fractures [47]. Other authors reported that after surgical treatment of non-union fractures of the navicular bone, the percentage of consolidation was higher in the group where extracorporeal shock wave therapy was performed [48].

There are few publications regarding non-union fractures of the humerus and clavicle. In particular, it was determined that after 3 months after the ESWT, the fusion occurred in 43.8%, and after 6 months in 52.5 % [49]. A clinical case findings were also published, in which the formation of bone regenerate was achieved after the treatment of a non-fused clavicle fracture by the ESWT method [50].

Chronic tendinopathy of the distal biceps tendon in 48 patients was treated with ESWT, showing safety and effectiveness of the method.

The number of publications by year is shown in Fig. 2, with a trend of increasing scientific interest in the use of the ESWT technique for the treatment of orthopedic and traumatological diseases of the upper limb: from 4 studies in 2016 to 10 in 2021.

Conclusions

Literature review showed that shock wave therapy is used in the treatment of lateral epicondylitis; calcifying tendinitis of the shoulder muscles; tendinopathy; partial injuries of the shoulder rotator muscles; subacromial impingement syndrome; adhesive capsulitis of the shoulder; non-union and slowly growing fractures; navicular bone of the wrist; hand diseases (carpal tunnel syndrome, snapping finger, Dupuytren's contracture, tendinopathies); fractures of the humerus and clavicle; tendinopathy of the distal tendon of the biceps brachii muscle.

ESWT has been shown to be a modern and effective method of conservative treatment of orthopedic and traumatological diseases of the upper limb, which can be used both independently and in combination with standard methods of conservative treatment.

Despite the increase in recent years of scientific research on the use of ESWT, there are currently no standardized protocols for the treatment of diseases and injuries of the upper extremity. Taking into account the perspective and effectiveness of the technique, further scientific development involving a larger number of treatment centers and patients is necessary.

Conflict of interest. The authors declare no conflict of interest.

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EFFECTIVENESS OF EXTRACORPOREAL SHOCK WAVE THERAPY DURING THE TREATMENT OF PATIENTS WITH ORTHOPEDIC AND TRAUMATOLOGICAL UPPER LIMBS DISEASES (LITERATURE REVIEW)

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