A Comprehensive Review of Extracorporeal Shockwave Therapy in the Management of Musculoskeletal Disorders: Efficacy, Mechanisms, and Clinical Applications

Article · August 2024

DOI: 10.5281/zenodo.13161695

Kriti Sachan

Sharda University

International Journal of Medical Science in Clinical Research and Review
Online ISSN: 2581-8945
Available Online at https://ijmscrr.in/ Volume 7|Issue 04 (July-August) |2024 Page: 835-842
Review Paper

A Comprehensive Review of Extracorporeal Shockwave Therapy in the Management of Musculoskeletal Disorders: Efficacy, Mechanisms, and Clinical Applications

Authors:
Afshan Perwez[1], Shivani Tiwari[1], Deepshikha Madhual[1], Manav Prasad[1], Kriti Sachan[2*]
[1]BPT Student, Department of Physiotherapy, Sharda School of Allied Health Sciences, Greater Noida, Uttar Pradesh, 201310, India.
[2]Assistant Professor, Department of Physiotherapy, Sharda School of Allied Health Sciences, Greater Noida, Uttar Pradesh, 201310, India.*
Corresponding Author:
Kriti Sachan, Assistant Professor, Department of Physiotherapy, Sharda School of Allied Health Sciences, Greater Noida, Uttar Pradesh, 201310, India

Article Received: 21-June-2024, Revised: 11-July-2024, Accepted: 01-August-2024

ABSTRACT:
Extracorporeal Shockwave Therapy (ESWT) has gained prominence as a non-invasive treatment option for various musculoskeletal disorders. This review examines the efficacy, underlying mechanisms, and clinical applications of ESWT, synthesizing current evidence from clinical studies, systematic reviews, and mechanistic research. The clinical efficacy of ESWT for common musculoskeletal conditions such as plantar fasciitis, tendinitis, and shoulder impingement syndrome. It synthesizes findings from randomized controlled trials and meta-analyses to compare ESWT with other treatment modalities, including physical therapy, corticosteroid injections, and surgical interventions. Evidence indicates that ESWT can significantly reduce pain and improve functional outcomes in many cases, although results can vary depending on the condition and treatment protocol. Mechanistic insights into ESWT are explored to understand how it exerts its therapeutic effects. The review highlights how ESWT influences cellular and molecular processes, including pain modulation, collagen synthesis, and angiogenesis. By promoting these biological responses, ESWT enhances tissue repair and alleviates symptoms associated with musculoskeletal injuries and chronic conditions. Clinical applications of ESWT are discussed, focusing on treatment protocols and parameters such as energy flux density, frequency, and duration of sessions. The review provides practical guidance on optimizing treatment regimens based on the specific musculoskeletal disorder being treated. It also addresses patient selection criteria and potential contraindications to ensure safe and effective use of ESWT. Safety considerations are reviewed, including common side effects and rare complications. The overall safety profile of ESWT is evaluated, with a discussion on the long-term implications of treatment. The existing research gaps and suggests directions for future research, including advancements in ESWT technology and the need for further studies to refine treatment protocols and enhance therapeutic outcomes. This comprehensive overview aims to inform clinicians and researchers about the current state of ESWT, offering insights into its effectiveness, mechanisms, and practical applications in managing musculoskeletal disorders.

Keywords: Extracorporeal Shockwave Therapy, Frozen shoulder, Trigger Finger, Plantar Fasciitis, Osteoarthritis, Achilles tendinitis.

INTRODUCTION:

Extracorporeal Shockwave Therapy (ESWT) has increasingly emerged as a non-invasive treatment modality for a variety of musculoskeletal disorders. Its application has expanded from its initial use in urology to a wide range of orthopedic and rehabilitation settings. The therapy utilizes acoustic waves to stimulate healing processes within the body, presenting a promising alternative or adjunct to conventional treatments. This introduction provides a comprehensive overview of ESWT, examining its historical development, mechanisms of action, clinical efficacy, and current applications in musculoskeletal medicine. [1]

Radiology plays a crucial role in enhancing the effectiveness and safety of Extracorporeal Shockwave Therapy (ESWT) for musculoskeletal disorders. Through various imaging techniques, radiology aids in the precise diagnosis, treatment planning, monitoring, and evaluation of ESWT outcomes.[2]

The most prevalent joint lesion, knee osteoarthritis (KOA), is also the main source of long-term bone and muscle discomfort, as well as impairment. Clinical manifestations include increasing stiffness, oedema, and discomfort in the knee joint. Severe cases may eventually lead to joint deformities and the inability to perform daily activities normally. The morbidity of KOA is rising globally as a result of the world's social population ageing more quickly KOA is treated by intra-articular injections, physiotherapy, exercise therapy, and oral medicine. Radial extracorporeal shock wave therapy (rESWT) is one of these therapies that has recently gained more interest. [3]

One common shoulder ailment is frozen shoulder, commonly known as adhesive capsulitis of the shoulder. Patients with this illness frequently report excruciating limitations to their active and passive ranges of motion as well as a progressive loss of shoulder motion.[3] Although the exact cause of this illness is unknown, a number of risk factors have been linked to it, such as female gender, diabetes, thyroid conditions, trauma, stroke, myocardial infarction, or a history of autoimmune illnesses.[4] The glenohumeral joint pathology known as adhesive capsulitis results in joint pain and immobility. While the efficacy of conservative treatment is still being investigated, ESWT is a useful supplementary therapy. [5]

10% of adults suffer from plantar fasciitis (PF), one of the most prevalent foot conditions. It involves biomechanical anomalies or excessive weight bearing (being fat or overusing the foot when bearing weight) that causes tension stresses on the plantar fascia, which results in degenerative and inflammatory alterations in the plantar fascia. [6] At the site where plantar fascia (Pf) attaches to the calcaneus, there is recurring micro-trauma that causes the plantar fascia to stretch and tear, resulting in an inflammatory disease. Most individuals with PF have unilateral Pf involvement, while about 30% of PF patients have bilateral involvement. About 85% of cases have an unknown aetiology. [7] Physical examination results and medical history are the main factors used to diagnose PF. For the diagnosis of PF, magnetic resonance imaging, ultrasonography, and plain radiography may be useful. Numerous other risk factors for plantar fasciitis have also been documented, such as a greater body mass index (BMI > 25), anatomical conditions such limb discrepancies, heel curvatures, prolonged standing, and decreased ankle dorsiflexion. Plantar fasciitis may benefit from the novel treatment technique known as extracorporeal shockwave therapy (ESWT). This treatment is recommended for individuals who do not respond to other therapies and is linked to regulating the injuries through an increase in growth factor.[8]
The hand condition known as trigger finger (TF), also called stenosing tenovaginitis or tenosynovitis, is caused by hypertrophy at the tendon's pulley intersection. This causes the tendon to constrict, which stops it from gliding through the ligament's pulley and results in pain, functional limitation, and a sudden release or locking of a finger during flexion or extension. Nodules can form as a result of pinching a tendon, and patients usually experience a popping or locking feeling as the nodule catches at the constriction.[9] The main method of diagnosing trigger finger is clinical, and it is linked to risk factors like feminine gender and ageing. The older population is frequently affected by it, particularly because diabetic mellitus (DM) is more common in this age range. The dominant hand's thumb and ring finger are frequently impacted. Acute trigger finger patients frequently have discomfort, edoema, and restricted range of motion in addition to the traditional presentation, which comprises finger popping and locking. It may be due to diseases like muco-polysaccharidoses, rheumatoid arthritis, or type 2 diabetes, or it may be idiopathic. According to certain research, trigger finger and hand overuse or repetitive hand damage are related. [10]
Historical Background and Technological Evolution
The origins of ESWT date back to the 1980s when it was first developed as a treatment for kidney stones. Its success in lithotripsy—the breaking of stones using shockwaves—paved the way for its exploration in other medical fields. As research progressed, clinicians observed that shockwaves could also influence soft tissue healing. This led to the adaptation of ESWT for treating musculoskeletal conditions, where it was hypothesized that the therapy could enhance tissue repair and alleviate pain.[11]
ESWT devices have evolved significantly since their inception. Early models focused on focused shockwaves, which deliver concentrated energy to a specific target area. More recent advancements include radial shockwave devices, which emit a broader, less focused wave, allowing for more versatile applications. The technological development of these devices has enhanced the precision, safety, and efficacy of ESWT, leading to its broader adoption in clinical practice.[12]

Mechanisms of Action:
Extracorporeal Shockwave Therapy (ESWT) operates through complex biological processes that stimulate tissue repair and pain relief. Understanding these mechanisms is crucial for optimizing treatment protocols and improving therapeutic outcomes. [14]

Biological Effects of Shockwaves:
Collagen Production and Remodeling: ESWT induces a controlled mechanical stress on tissues, leading to micro-trauma and activation of the body's repair mechanisms. This mechanical stimulation enhances the synthesis and organization of collagen fibers, which are vital for tendon and ligament repair. Studies have demonstrated that ESWT increases the expression of collagen types I and III, contributing to improved tissue strength and function. [15]

Pain Modulation and Endogenous Pain Control: The pain-relieving effects of ESWT are partly attributed to its impact on pain pathways. Shockwaves can modulate the release of pain-mediating substances, such as prostaglandins and cytokines, and influence neural mechanisms involved in pain perception. Additionally, ESWT may activate endogenous pain control systems, including the release of endorphins and activation of descending inhibitory pathways.

Microcirculation and Angiogenesis: ESWT enhances local blood flow and promotes angiogenesis, which are crucial for tissue healing. The mechanical stimulation increases the expression of angiogenic factors like vascular endothelial growth factor (VEGF) and fibroblast growth factor (FGF), leading to the formation of new blood vessels. This improved microcirculation enhances the delivery of oxygen and nutrients to the damaged tissue, facilitating repair and regeneration. [16]

Cellular and Molecular Responses:

Impact on Fibroblasts and Tenocytes: Shockwave therapy affects fibroblasts and tenocytes, which are key cells involved in tissue repair. ESWT stimulates these cells to proliferate and produce extracellular matrix components, including collagen and glycosaminoglycans. This cellular response is essential for the remodeling of damaged tissues and restoration of function.

Influence on Growth Factors and Cytokines: ESWT modulates the release of growth factors and cytokines that play a role in tissue repair. Increased levels of growth factors such as transforming growth factor-beta (TGF-β) and platelet-derived growth factor (PDGF) have been observed following ESWT, supporting the healing process. Additionally, ESWT reduces the levels of pro-inflammatory cytokines, thereby decreasing inflammation and promoting tissue recovery. [17]

Theoretical Models of Shockwave Interaction with Tissues:

The theoretical models of ESWT interaction with tissues involve the transmission of acoustic waves through the skin and underlying tissues. The shockwaves create high-pressure waves that result in cavitation, or the formation of microbubbles, which subsequently collapse and produce localized shock forces. These forces generate microtrauma and stimulate the tissue repair process. Understanding these models helps in optimizing ESWT parameters and improving clinical outcomes.[18]

Clinical Efficacy:

The clinical efficacy of ESWT has been extensively studied across various musculoskeletal disorders. This section reviews the current evidence regarding its effectiveness in treating common conditions, compares it with other therapeutic options, and addresses variability in outcomes.

Evaluation of ESWT for Common Musculoskeletal Conditions:

Plantar Fasciitis: ESWT has been shown to be effective in reducing pain and improving function in patients with plantar fasciitis. Several randomized controlled trials (RCTs) and meta-analyses indicate significant improvements in pain levels and functional status following ESWT. The therapy is thought to promote collagen remodeling and reduce inflammation in the plantar fascia.[19]

Tendinitis: For conditions such as Achilles tendinitis and lateral epicondylitis (tennis elbow), ESWT has demonstrated positive outcomes. Clinical studies report reductions in pain and improvements in functional scores. The efficacy of ESWT in tendinitis is attributed to its effects on collagen production and microcirculation, which aid in the healing of tendinopathic tissues.[20]

Shoulder Impingement Syndrome: ESWT has also been evaluated for shoulder impingement syndrome, with studies indicating beneficial effects in terms of pain relief and functional improvement. The therapy may enhance local blood flow and reduce inflammation in the shoulder joint, contributing to symptom relief and improved range of motion.[21]

Comparative Effectiveness:

ESWT vs. Physical Therapy: Comparative studies suggest that ESWT can be as effective as or more effective than traditional physical therapy in certain conditions. While physical therapy focuses on exercise and manual techniques, ESWT provides a direct mechanical stimulus to the affected area. The choice between ESWT and physical therapy often depends on the specific condition and patient preferences.[22]

ESWT vs. Corticosteroid Injections: ESWT is generally considered a safer alternative to corticosteroid injections, which carry risks of side effects such as joint damage and systemic effects. Clinical trials have shown that ESWT can provide comparable pain relief and functional improvement without the potential adverse effects associated with corticosteroids.[23]

ESWT vs. Surgical Interventions: In some cases, ESWT has been used as a non-surgical option before considering invasive procedures. While ESWT may not always replace the need for surgery, it can be an effective conservative treatment that reduces the need for more invasive interventions.[24]

Variability in Outcomes:

Factors Influencing Efficacy: The effectiveness of ESWT can vary based on several factors, including the specific musculoskeletal condition, the ESWT parameters used, and individual patient characteristics. Factors such as the duration of symptoms, severity of the condition, and adherence to treatment protocols can influence outcomes.[25]

Patient-Specific Considerations: Individual response to ESWT can vary, and not all patients may experience significant benefits. Patient factors such as age, overall health, and comorbidities can affect treatment outcomes. Tailoring treatment protocols to individual needs and conditions is essential for maximizing efficacy.[26]

Current Clinical Applications:

ESWT is currently employed in various clinical settings for the management of musculoskeletal disorders. This section outlines its applications in orthopedic practice, sports medicine, and bone conditions.[27]

Applications in Orthopedic Practice:

Tendon and Ligament Injuries: ESWT is widely used in orthopedic practice to treat tendon and ligament injuries, including rotator cuff tendinopathy, Achilles tendinitis, and medial collateral ligament injuries. The therapy helps alleviate pain, promote healing, and improve functional outcomes in these conditions.[28]

Soft Tissue Disorders: In addition to tendon and ligament injuries, ESWT is applied to other soft tissue disorders such as bursitis and myofascial pain syndrome. By reducing inflammation and enhancing tissue repair, ESWT provides relief from chronic pain and discomfort associated with these conditions.[29]

Sports Medicine Applications

Rehabilitation of Athletic Injuries: ESWT is commonly used in sports medicine for the rehabilitation of athletic injuries. The therapy aids in the recovery of injuries such as muscle strains, tendon injuries, and joint sprains. By accelerating the healing process and reducing pain, ESWT helps athletes return to their activities more quickly.[30]

Enhancement of Recovery: ESWT is also utilized to enhance recovery following sports-related injuries. The therapy's ability to improve tissue repair and reduce inflammation supports a faster and more effective recovery process.[31]

Use in Bone Conditions:

Delayed Fracture Healing: ESWT has shown promise in treating delayed fracture healing and non-union fractures. The therapy stimulates bone repair by enhancing cellular activity and promoting angiogenesis, which are critical for fracture healing.[32]

Non-Union Fractures: For non-union fractures that fail to heal with conventional treatments, ESWT provides an alternative option. The therapy can improve the chances of successful bone union by promoting cellular and vascular responses in the affected area.[33]

Safety and Adverse Effects:

The safety profile of ESWT is an important consideration for its clinical use. This section reviews common side effects, rare complications, and contraindications associated with ESWT.[34]

Common Side Effects:

Pain and Discomfort: Transient pain and discomfort at the treatment site are common side effects of ESWT. These effects are usually mild and temporary, often resolving within a few hours to days after treatment.[35]

Erythema and Swelling: Mild erythema (redness) and swelling at the treatment site may occur following ESWT. These effects are generally short-lived and resolve without intervention.[36]

Rare Complications:

Potential Severe Adverse Effects: Severe adverse effects are rare but can include skin bruising, blistering, or more serious complications such as nerve injury. Proper application of ESWT and adherence to treatment guidelines help minimize the risk of severe complications.

Risk Mitigation Strategies: To mitigate risks, it is important to follow established protocols, conduct thorough patient assessments, and use appropriate ESWT devices. Ensuring that ESWT is performed by trained professionals reduces the likelihood of adverse effects.[37]

Contraindications:

Contraindicated Conditions: ESWT is contraindicated in certain conditions, including pregnancy, malignancy, and active infections. Additionally, caution is advised in patients with bleeding disorders or those who have recently undergone surgery in the treatment area.[38]

Precautionary Measures: When ESWT is used in patients with contraindications or comorbidities, precautionary measures should be taken to ensure safety. This includes careful screening and monitoring throughout the treatment process.[39]

Future Directions and Research:

The field of Extracorporeal Shockwave Therapy (ESWT) is dynamic and continuously advancing, with ongoing research aimed at refining its efficacy, exploring new applications, and addressing existing limitations. This section discusses key areas of future research and potential directions that could shape the future of ESWT in the management of musculoskeletal disorders.[40]

CONCLUSION:

Extracorporeal Shockwave Therapy (ESWT) has become a notable non-invasive treatment option for managing various musculoskeletal disorders, demonstrating substantial effectiveness in alleviating pain and enhancing functional outcomes. The therapy operates through a complex interplay of biological mechanisms, including the stimulation of collagen production, modulation of pain pathways, and improvement of microcirculation. These mechanisms collectively contribute to its ability to promote tissue repair and reduce discomfort in conditions such as plantar fasciitis, tendinitis, and shoulder impingement syndrome. The growing body of evidence from clinical studies and trials supports ESWT's efficacy, showing that it can rival or even surpass other conservative treatments, such as physical therapy and corticosteroid injections, in certain scenarios. The versatility of ESWT allows its application in various clinical settings, including orthopedic practices and sports medicine, addressing both soft tissue injuries and bone conditions like delayed fracture healing and non-union fractures. Despite its generally positive safety profile, with common side effects being mild and transient, the therapy is not without risks. Rare complications can occur, emphasizing the importance of adhering to established protocols and contraindications to ensure patient safety. Ongoing research is critical to address several areas that could enhance the application and outcomes of ESWT. Future studies should focus on optimizing treatment parameters, such as energy flux density and frequency, to determine the most effective protocols for different musculoskeletal conditions. Personalization of treatment plans based on individual patient characteristics and specific conditions could further improve efficacy and reduce variability in outcomes. Additionally, exploring the synergistic effects of combining ESWT with other therapeutic modalities, such as physical therapy or pharmacological treatments, may offer more comprehensive management options and enhance overall treatment success. Technological advancements in ESWT devices and delivery methods hold promise for improving treatment precision and patient comfort. Innovations such as advanced shockwave generators and imaging-guided techniques could revolutionize the way ESWT is administered, making it more effective and adaptable to diverse clinical needs. Addressing existing research gaps, including long-term effects and the impact of ESWT on various patient populations, will provide a more comprehensive understanding of its benefits and limitations. The field of ESWT is dynamic and continually evolving, with the potential to significantly impact musculoskeletal medicine. As new evidence emerges and technology advances, ESWT is expected to play an increasingly integral role in the management of musculoskeletal disorders. By staying informed about the latest research and developments, clinicians can optimize ESWT protocols, personalize treatments, and offer improved care to patients. In summary, ESWT represents a valuable and evolving treatment modality that, with ongoing research and technological advancements, holds the potential to further enhance patient outcomes and redefine the management of musculoskeletal conditions.

REFERENCES:

1. Xu Y, Wu K, Liu Y, Geng H, Zhang H, Liu S, Qu H, Xing G. The effect of extracorporeal shock wave therapy on the treatment of moderate to severe knee osteoarthritis and cartilage lesion. Medicine. 2019 May 1;98(20):e15523.
2. Chouhan, A.P.S., Verma, A. and Singh, V., 2024. The Significance of Nanomaterials in Medical Imaging and Diagnostics. In *Cutting-Edge Applications of Nanomaterials in Biomedical Sciences* (pp. 301-325). IGI Global.
3. Cao DZ, Wang CL, Qing Z, Liu LD. Effectiveness of extracorporeal shock-wave therapy for frozen shoulder: a protocol for a systematic review of randomized controlled trial. Medicine. 2019 Feb 1;98(7):e14506.
4. Qiao HY, Xin L, Wu SL. Analgesic effect of extracorporeal shock-wave therapy for frozen shoulder: A randomized controlled trial protocol. Medicine. 2020 Jul 31;99(31):e21399.
5. Kola I, Mata D, Novruzaj E, Sherifi R. Diagnosis and treatment of frozen shoulder with shock-wave

therapy. Medical & Clinical Research. 2022 Oct 5;7(10):1-3.

6. Cinar E, Saxena S, Akkurt HE, Uygur F. Extracorporeal shockwave therapy in the management of plantar fasciitis: A randomized controlled trial. The Foot. 2020 Sep 1;44:101679.
7. Koz G, Kamanli A, Kaban N, Harman H. Efficacies of extracorporeal shockwave therapy and low-level laser therapy in patients with plantar fasciitis. Foot and Ankle Surgery. 2023 Apr 1;29(3):223-7.
8. Haddad S, Yavari P, Mozafari S, Farzinnia S, Mohammadsharifi G. Platelet-rich plasma or extracorporeal shockwave therapy for plantar fasciitis. International Journal of Burns and Trauma. 2021;11(1):1
9. Ferrara PE, Codazza S, Maccauro G, Zirio G, Ferriero G, Ronconi G. Physical therapies for the conservative treatment of the trigger finger: a narrative review. Orthopedic Reviews. 2020 Jun 6;12(Suppl 1).
10. El-Leithy SA, Adly NN, Taha RM, El-Gharbawy NH. Extra-corporeal shock wave therapy versus local corticosteroid injection in treatment of chronic trigger finger in diabetic patients. Egyptian Rheumatology and Rehabilitation. 2023 Nov 13;50(1):57.
11. Wang B, Wang XL, Ma YT, Wu W, Zheng YJ. Evaluation of the efficacy of trigger points combined with extracorporeal shock waves in the treatment of plantar fasciitis: heel temperature and plantar pressure. BMC Musculoskeletal Disorders. 2024 Mar 2;25(1):191.
12. HyoJeong ON, JongEun YI. Effects of local vibration combined with extracorporeal shock wave therapy in plantar fasciitis: a randomized controlled trial. Journal of Rehabilitation Medicine. 2023;55.
13. Carlisi E, Manzoni F, Maestri G, Boschi LM, Lisi C. Short-Term Outcome of Focused Shock Wave Therapy for Sural Myofascial Pain Syndrome associated with Plantar Fasciitis: a Randomized Controlled Trial. Muscles, Ligaments & Tendons Journal (MLTJ). 2021 Jul 1;11(3).
14. Cinar E, Saxena S, Akkurt HE, Uygur F. Extracorporeal shockwave therapy in the management of plantar fasciitis: A randomized controlled trial. The Foot. 2020 Sep 1;44:101679.
15. Chanu KP, Bimol N, Singh YN, Venyo V, Das R, Deb D. Effectiveness of Extracorporeal shock wave therapy in the management of Plantar fasciitis: a Randomized Controlled Trial. IOSR Journal of Dental and Medical Sciences. 2019;18(11):16-9.
16. Mishra BN, Poudel RR, Banskota B, Shrestha BK, Banskota AK. Effectiveness of extra-corporeal shock wave therapy (ESWT) vs methylprednisolone injections in plantar fasciitis. Journal of clinical orthopaedics and trauma. 2019 Mar 1;10(2):401-5.
17. El-Leithy SA, Adly NN, Taha RM, El-Gharbawy NH. Extra-corporeal shock wave therapy versus local corticosteroid injection in treatment of chronic trigger finger in diabetic patients. Egyptian Rheumatology and Rehabilitation. 2023 Nov 13;50(1):57.
18. Ahmed RA, Arfa MM, Ahmed SF, EL-Gharbawy NH. The Role of Extra Corporeal Shockwave in Treatment of Trigger Finger. QJM: An International Journal of Medicine. 2023 Jun 1;116(Supplement_1):hcad069-682.

19. Wah YC, Yi CZ, Singh K, Hua KK, Govind S, Chandrakasan V. Comparing the Effect of Combined Therapy of Extracorporeal Shock Wave Therapy and Ice Massage with Combined Therapy of Therapeutic Ultrasound with Paraffin Wax Bath in Treating Trigger Finger. Indian Journal of Forensic Medicine & Toxicology. 2020 Oct 29;14(4):7794-801.
20. Chen YP, Lin CY, Kuo YJ, Lee OK. Extracorporeal shockwave therapy in the treatment of trigger finger: a randomized controlled study. Archives of Physical Medicine and Rehabilitation. 2021 Nov 1;102(11):2083-90.
21. Vahdatpour B, Momeni F, Tahmasebi A, Taheri P. The effect of extracorporeal shock wave therapy in the treatment of patients with trigger finger. Open Access Journal of Sports Medicine. 2020 Mar 9:85-91.
22. Yildirim P, Gultekin A, Yildirim A, Karahan AY, Tok F. Extracorporeal shock wave therapy versus corticosteroid injection in the treatment of trigger finger: a randomized controlled study. Journal of Hand Surgery (European Volume). 2016 Nov;41(9):977-83.
23. Elgendy MH, Elsamahy SA, Mostafa MS, Hamza MS. Efficacy of shockwave therapy versus intra-articular platelet-rich plasma injection in management of knee osteoarthritis: a randomized controlled trial. Int J Pharm Res. 2020 Oct 1;12(4):4283-9.
24. Hammam RF, Kamel RM, Draz AH, Azzam AA, El Kasem ST. Comparison of the effects between low-versus medium-energy radial extracorporeal shock wave therapy on knee osteoarthritis: A randomised controlled trial. Journal of Taibah University Medical Sciences. 2020 Jun 1;15(3):190-6.
25. Eftekharsadat B, Jahanjoo F, Toopchizadeh V, Heidari F, Ahmadi R, Babaei-Ghazani A. Extracorporeal shockwave therapy and physiotherapy in patients with moderate knee osteoarthritis.
26. Elgendy MH, Elsamahy SA, Mostafa MS, Hamza MS. Efficacy of shockwave therapy versus intra-articular platelet-rich plasma injection in management of knee osteoarthritis: a randomized controlled trial. Int J Pharm Res. 2020 Oct 1;12(4):4283-9.
27. Zhong Z, Liu B, Liu G, Chen J, Li Y, Chen J, Liu X, Hu Y. A randomized controlled trial on the effects of low-dose extracorporeal shockwave therapy in patients with knee osteoarthritis. Archives of physical medicine and rehabilitation. 2019 Sep 1;100(9):1695-702.
28. Ammar T. Shock wave therapy versus interferential therapy in knee osteoarthritis. Int J Physiother Res. 2018;6(3):2771-76. Pinitkwamdee S, Laohajaroensombat S, Orapin J, Woratanarat P. Effectiveness of extracorporeal shockwave therapy in the treatment of chronic insertional Achilles tendinopathy. Foot & ankle international. 2020 Apr;41(4):403-10.
29. Gatz M, Schweda S, Betsch M, Dirrichs T, de la Fuente M, Reinhardt N, Quack V. Line-and point-focused extracorporeal shock wave therapy for Achilles tendinopathy: a placebo-controlled RCT study. Sports Health. 2021 Sep;13(5):511-8.
30. Awaz Pinitkwamdee S, Laohajaroensombat S, Orapin J, Woratanarat P. Effectiveness of extracorporeal shockwave therapy in the treatment

of chronic insertional Achilles tendinopathy. Foot & ankle international. 2020 Apr;41(4):403-10.
31. Zhang S, Li H, Yao W, Hua Y, Li Y. Therapeutic response of extracorporeal shock wave therapy for insertional Achilles tendinopathy between sports-active and nonsports-active patients with 5-year follow-up. Orthopaedic Journal of Sports Medicine. 2020 Jan 22;8(1):2325967119898118.
32. Dedes V, Mitseas A, Polikandrioti M, Dede AM, Perrea A, Soldatos T, Panoutsopoulos GI. Achilles tendinopathy: Comparison between shockwave and ultrasound therapy. Int J Phys Educ Sports Health. 2020; 7:239-43.
33. EL-Mallah R, Elattar EA. Extracorporeal shockwave therapy versus musculoskeletal mesotherapy for Achilles tendinopathy in athlete. Egyptian Rheumatology and Rehabilitation. 2020 Dec; 47:1-0.
34. Vahdatpour B, Forouzan H, Momeni F, Ahmadi M, Taheri P. Effectiveness of extracorporeal shockwave therapy for chronic Achilles tendinopathy: a randomized clinical trial. Journal of Research in Medical Sciences. 2018 Jan 1;23(1):37.
35. Elerian AE, Rodriguez-Sanz D, Abdelaziz Elsherif A, Dorgham HA, Al-Hamaky DM, El Fakharany MS, Ewidea M. Effectiveness of shock wave therapy versus intra-articular corticosteroid injection in diabetic frozen shoulder patients' management: randomized controlled trial. Applied Sciences. 2021 Apr 20;11(8):3721.
36. Qiao HY, Xin L, Wu SL. Analgesic effect of extracorporeal shock-wave therapy for frozen shoulder: A randomized controlled trial protocol. Medicine. 2020 Jul 31;99(31): e21399.
37. Muthukrishnan R, Rashid AA, Al-Alkharji F. The effectiveness of extracorporeal shockwave therapy for frozen shoulder in patients with diabetes: randomized control trial. Journal of physical therapy science. 2019;31(7):493-7.
38. Otafirda MV, Prabowo T, Goesasi RZ. A Preliminary Study on the Effect of Low Energy Extracorporeal Shock Wave Therapy as a Treatment for Shoulder Adhesive Capsulitis in Hasan Sadikin Hospital Bandung, Indonesia.
39. Alarab A, Shameh RA, Shaheen H, Ahmad MS. Shock Wave Therapy and Ultrasound Therapy plus Exercises for Frozen Shoulder Joint Clients. Adv Nursing Patient Care Int J. 2018;1(2):1-7.
40. Lee S, Lee S, Jeong M, Oh H, Lee K. The effects of extracorporeal shock wave therapy on pain and range of motion in patients with adhesive capsulitis. Journal of physical therapy science. 2017;29(11):1907-9.