THE ROLE OF ULTRASOUND IN MUSCULOSKELETAL IMAGING: A RADIOLOGICAL AND PHYSIOTHERAPEUTIC PERSPECTIVE

Hamad Ali Hassan Al Saimah[1], Mohammed Saleh Saud Almerdaf[2], Mana Abdullah Saleh Al Abbas[3], Salem Mohammed Hussien Almansour[4], Ali Hamad Ali Alyami[5], Kudaysi Hadi Jaber Al Sallum[6], Salem Mubarak Algahes[7], Saeed Mesfer Ali Alyami[8]

Abstract:

Background: Ultrasound diagnostic imaging (USI) is increasingly used in sports medicine, orthopedics, and rehabilitation due to its advantages such as being radiation-free, cost-effective, portable, and non-invasive. Musculoskeletal USI provides valuable information for assessing musculoskeletal structures and function, aiding in prompt diagnosis and treatment planning. Physical therapists (PTs) play a crucial role in musculoskeletal care, with a practice framework emphasizing anatomy, pathoanatomy, and biomechanics. However, there is a reported gap in PTs' knowledge and skills regarding the utilization of USI compared to other imaging modalities like radiography and MRI. **Objective**: This study aims to explore the current utilization of ultrasound in musculoskeletal imaging within physiotherapy, evaluate its effectiveness in diagnosing and monitoring musculoskeletal conditions, and assess its role in therapeutic interventions in physiotherapy practice. **Conclusion**: Musculoskeletal ultrasound has shown promise in diagnosing various conditions such as meniscal injuries, ligament tears, tendon pathologies, and nerve injuries. Dynamic ultrasound protocols enable real-time visualization of structures during movement, aiding in accurate assessments. Additionally, interventional ultrasound can guide treatment interventions, such as needle placements for injections or hydrodissection procedures. Moreover, therapeutic ultrasound, particularly Low-intensity pulsed ultrasound (LIPUS), has emerged as a non-invasive modality for promoting tissue regeneration and managing soft tissue injuries. Studies have highlighted the effectiveness of LIPUS in accelerating fracture healing, reducing inflammation, and modulating neural activity in various soft tissues. Overall, integrating ultrasound into physiotherapy practice can enhance diagnostic accuracy, treatment precision, and patient outcomes in musculoskeletal care.

Keywords: Musculoskeletal Ultrasound, PT imaging, Physical therapy.

[1*]Nurse, New Najran General hospital, Najran, Saudi Arabia
[2]Nurse, Yadamah Geniral Hospital, Najran, Saudi Arabia
[3]X-ray technician, Dahdha Health Centre, Najran, Saudi Arabia
[4]X-Ray Technition, New Najran General Hospital, Najran, Saudi Arabia
[5]Physical therapist, Khabash General Hospital, Najran, Saudi Arabia
[6]Physical therapist, Thar General Hospital, Najran, Saudi Arabia
[7]Specialist of Radiological Technology, Radiology management and applied services, Najran, Saudi Arabia
[8]Technician of Emergency Medical Services, Khabash General Hospital, Najran, Saudi Arabia, Najran, Saudi Arabia

***Corresponding Author:** Hamad Ali Hassan Al Saimah
*Nurse, New Najran General hospital, Najran, Saudi Arabia

DOI: 10.53555/ecb/2022.11.11.197

Introduction:

Ultrasound diagnostic imaging (USI) is increasingly being employed in the fields of sports medicine, orthopaedics, and rehabilitation to complement physical examinations and expedite the diagnostic process, thereby reducing delays in treatment. The expanding range of indications for USI is attributed to its numerous advantages when compared to other imaging modalities. These advantages include the absence of radiation exposure, cost-effectiveness, ease of portability, and its non-invasive nature [1].

Healthcare providers can promptly obtain detailed imaging information for a wide array of patient conditions using musculoskeletal USI. This imaging modality has emerged as a valuable tool for the objective assessment of musculoskeletal structures, both structurally and functionally, particularly during assessments of range of motion and muscle activation in both static and dynamic settings [2].

Physical therapists (PTs) possess a distinctive practice framework and scope of practice that sets them apart from other healthcare professionals. Their practice framework emphasizes a deep understanding of anatomy, pathoanatomy, and biomechanics of movement. Therefore, exploring the published literature on the utilization of musculoskeletal USI in physical therapist practice could offer unique insights into the advantages of incorporating this imaging modality into their clinical assessments [3].

A survey conducted among PTs in the United States revealed that out of 646 respondents, 241 had recommended or referred patients for USI. However, the survey participants indicated a greater level of knowledge and confidence in recommending or ordering conventional imaging modalities such as radiography (x-ray) and magnetic resonance imaging (MRI) over USI. This suggests a potential gap in understanding and utilization of USI among PTs, highlighting the need for increased awareness and education on the benefits and appropriate applications of USI in clinical practice [4].

Furthermore, ultrasound technology can also be harnessed in the management of musculoskeletal soft tissue injuries through techniques such as Low-intensity pulsed ultrasound (LIPUS). LIPUS, a form of mechanical stimulation, has gained popularity as a non-invasive therapeutic modality in the fields of traumatology and regenerative medicine, offering promising outcomes for patients with such conditions.

Objectives:

The main objectives of this review are:

1. to explore the current utilization of ultrasound in musculoskeletal imaging within the field of physiotherapy.
2. to evaluate the effectiveness of ultrasound in diagnosing and monitoring musculoskeletal conditions.
3. to assess the role of therapeutic ultrasound in physiotherapy practice.

Diagnostic MSK Ultrasound:

Physical therapists (PTs) do not engage in medical diagnoses; however, they assess pathoanatomic structures to formulate a physical therapy diagnosis. By identifying structural lesions that fall beyond the realm of physical therapy practice, such as fractures, PTs can promptly refer patients to appropriate healthcare providers if necessary. Research has demonstrated that musculoskeletal ultrasound (MSK-US) is a cost-effective tool for diagnosing structural pathologies [5].

In certain musculoskeletal (MSK) conditions, ultrasound has proven to be as effective as or even superior to MRI in accurately diagnosing injuries like meniscal injuries, ACL and PCL injuries, Achilles tendinopathy, peripheral nerve injuries, lateral epicondylitis, thumb ulnar collateral ligament injuries, rotator cuff tears, and supraspinatus lesions. However, there are specific MSK injuries, such as distal biceps tendon avulsions and plantar plates, where ultrasound may not be as comparable to MRI. Additionally, MSK-US is utilized in assessing acute athletic injuries [6].

There is a growing interest in the capability of ultrasound to observe muscles both statically and dynamically. International experts have developed dynamic ultrasound protocols to aid clinicians in evaluating structures by recording real-time videos during patient examinations, enhancing their comprehension of diagnoses. Dynamic ultrasound enables the real-time visualization of structures in motion relative to other structures. For instance, during active muscle contraction, clinicians can assess fascial mobility by observing the movement of adjacent fascial layers. Muscle architecture can be scrutinized for deficiencies under both contraction and relaxation states [7].

Interventional Musculoskeletal Ultrasound:

According to a case study by Silleves et al. [8], physical therapists can incorporate Musculoskeletal Ultrasound (MSK-US) into their treatment strategies to provide guidance for interventions. The study highlighted a runner with plantar fasciitis whose treatment was guided by MSK-US imaging to ensure precise decision-making regarding the location and progress of the treatment. While the use of MSK-US to assist in needle placement for dry needling has gained popularity among physical therapists, a study suggested that there may not be any additional benefits of using US-guided dry needling in chronic neck pain patients.

Typically, interventional MSK-US procedures involve practitioners administering injections. Although this falls outside the usual scope of practice for most physical therapists, MSK-US enables accurate needle placement for injecting anti-inflammatory medications or during prolotherapy. A relatively new technique called "hydrodissection" has emerged in musculoskeletal medicine, where MSK-US is utilized to guide hypodermic needles into muscles and fascia for injecting saline. This process aims to break up adhesions and enhance fascial mobility [9].

Therapeutic Ultrasound in Musculoskeletal Soft Tissue Injuries:

Musculoskeletal soft tissues encompass tendons, ligaments, cartilage, joint capsules, and muscles. While severe injuries necessitate immediate medical attention, many individuals with minor soft tissue injuries may go undiagnosed and untreated, assuming it won't significantly impact their daily lives [10]. This delay in seeking treatment can lead to chronic conditions, making treatment more complex and reducing patients' quality of life. Challenges in musculoskeletal soft tissue regeneration, such as excessive inflammation, infection, and size defects, further complicate the healing process [11].

When intrinsic regenerative capabilities are insufficient, autologous or allogeneic transplantation becomes a viable option. However, complications like donor site issues, rejection, and infections may arise with these grafts [12]. Therefore, the integration of adjuvant therapies to enhance tissue regeneration is crucial for improving quality of life and extending productive years. Low-Intensity Pulsed Ultrasound (LIPUS), a non-invasive therapeutic modality based on mechanical stimulation, has gained popularity in traumatology and regenerative medicine [13].

Over the years, ultrasound applications in medicine, particularly for diagnostics, surgery, and therapy, have been extensively researched. Studies have shown that LIPUS can expedite the healing process of fresh fractures, nonunion fractures, and delayed union fractures in both animal and clinical settings [14]. Additionally, LIPUS has demonstrated effectiveness in promoting soft tissue regeneration and reducing inflammatory responses. Recent research has also highlighted the potential of LIPUS in modulating neural activity, indicating its promise in various therapeutic applications [15].

Mechanisms of LIPUS in different soft tissues:

The mechanisms of Low-Intensity Pulsed Ultrasound (LIPUS) in various soft tissues have been studied extensively. In the case of tendon, ligament, and bone-tendon junction (BTJ) injuries, LIPUS therapy has shown promising results. The BTJ, which is the transitional area between tendons and bones, poses challenges in terms of recovery compared to other types of tissue-to-tissue healing. Injuries involving the BTJ, especially around joints like the knee, are common in sports, exercise, and auto accidents [16].

Recent studies have highlighted the effectiveness of LIPUS in enhancing the healing of tendon injuries. For instance, Li et al. observed significant improvements in the failure load and stiffness of the supraspinatus tendon-humerus junction in the LIPUS group at postoperative weeks 2 and 4. This improvement was linked to the involvement of macrophages. Chen et al. utilized a combination of LIPUS and adipose-derived mesenchymal stem cell implantation to treat a rabbit model with partial patellectomy, resulting in increased bone formation and enhanced regeneration of fibrocartilage. Additionally, Lu et al. demonstrated the efficacy of LIPUS in improving the mechanical properties of the BTJ of the patellar through its anti-inflammatory effects [17].

In the context of skeletal muscle injuries, which are common in sports and daily activities, the healing process involves several phases such as inflammation, repair, and remodeling [18]. While some studies have shown inconclusive results regarding the effectiveness of LIPUS in aiding muscle restoration, recent research has highlighted its protective effects on muscle recovery from various perspectives [19].

Oxidative stress plays a crucial role in muscle healing, particularly in the initial inflammatory phase. Excessive production of reactive oxygen species can contribute to muscle damage. Freitas et al. investigated the impact of LIPUS on oxidative stress parameters and found that LIPUS reduced levels of thiobarbituric acid-reactive substances (TBARS) and inhibited the activities of catalase and superoxide dismutase (SOD) in the early stages after muscle contusion. This suggests that LIPUS can protect muscle tissue from oxidative injury and may have a stronger antioxidant effect when combined with other therapeutic modalities [20].

Conclusion:

In conclusion, ultrasound imaging plays a crucial role in musculoskeletal diagnostics and interventions from both radiological and physiotherapeutic perspectives. The utilization of ultrasound in musculoskeletal imaging within physiotherapy has shown promising results in diagnosing and monitoring various conditions, such as meniscal injuries, ligament tears, and muscle pathologies. Therapeutic ultrasound, particularly Low-intensity pulsed ultrasound (LIPUS), has emerged as a non-invasive modality with potential benefits in promoting soft tissue regeneration and inhibiting inflammatory responses. The integration of ultrasound into physical therapy interventions, such as guiding treatments and injections, has shown positive outcomes in improving patient care. Further research and awareness in the field of musculoskeletal ultrasound can enhance its appropriate utilization and effectiveness in clinical practice, benefiting both patients and healthcare providers alike.

References:

1. Pillen S, van Alfen N. Skeletal muscle ultrasound. Neurol Res. 2011;33(10):1016-1024. doi:10.1179/1743132811y.0000000010 [PubMed] [Google Scholar]
2. Whittaker JL, Teyhen DS, Elliott JM, et al. Rehabilitative ultrasound imaging: understanding the technology and its applications. J Orthop Sports Phys Ther. 2007;37(8):434-449. doi:10.2519/jospt.2007.2350 [PubMed] [Google Scholar]
3. American Physical Therapy Association. Physical Therapist's Scope of Practice. Published September 13, 2017. Accessed February 1, 2022. https://www.apta.org/apta-and-you/leadership-and-governance/policies/position-scope-of-practice
4. Rundell SD, Maitland ME, Manske RC, Beneck GJ. Survey of physical therapists' attitudes, knowledge, and behaviors regarding diagnostic imaging. Phys Ther. 2021;101(1). doi:10.1093/ptj/pzaa187 [PubMed] [Google Scholar]
5. Bureau NJ, Ziegler D. Economics of musculoskeletal ultrasound. Curr Radiol Rep. 2016;4(8):44. doi:10.1007/s40134-016-0169-5 [PMC free article] [PubMed] [Google Scholar]
6. Duan X, Li L, Wei DQ, et al. Role of magnetic resonance imaging versus ultrasound for detection of plantar plate tear. J Orthop Surg Res. 2017;12(1):14. doi:10.1186/s13018-016-0507-6 [PMC free article] [PubMed] [Google Scholar]
7. Ricci V, Chang KV, Güvener O, et al. EURO-MUSCULUS/USPRM Dynamic ultrasound protocols for shoulder. Am J Phys Med Rehabil. 2022;101(3):e29-e36. doi:10.1097/phm.0000000000001833 [PubMed] [Google Scholar]
8. Sillevis R, Shamus E, Mouttet B. The management of plantar fasciitis with a musculoskeletal ultrasound imaging guided approach for instrument assisted soft tissue mobilization in a runner: a case report. *Int J Sports Phys Ther*. 2020;15(2):274-286. doi:10.26603/ijspt20200274 [PMC free article] [PubMed] [Google Scholar]
9. Kaga M. First case of occipital neuralgia treated by fascial hydrodissection. *Am J Case Rep*. 2022;23:e936475. doi:10.12659/ajcr.936475 [PMC free article] [PubMed] [Google Scholar]
10. Gwyer D., Wragg N. M., Wilson S. L. (2019). Gastric pentadecapeptide body protection compound BPC 157 and its role in accelerating musculoskeletal soft tissue healing. *Cell Tissue Res.* 377 (2), 153–159. 10.1007/s00441-019-03016-8 [PubMed] [CrossRef] [Google Scholar] [Ref list]
11. Ryan T. J. (2007). Infection following soft tissue injury: Its role in wound healing. *Curr. Opin. Infect. Dis.* 20 (2), 124–128. 10.1097/qco.0b013e32801a3e7c [PubMed] [CrossRef] [Google Scholar] [Ref list]
12. Ducic I., Yoon J., Buncke G. (2020). Chronic postoperative complications and donor site morbidity after sural nerve autograft harvest or biopsy. *Microsurgery* 40 (6), 710–716. 10.1002/micr.30588 [PMC free article] [PubMed] [CrossRef] [Google Scholar] [Ref list]
13. Mei L., Zhang Z. (2021). Advances in biological application of and research on low-frequency ultrasound. *Ultrasound Med. Biol.* 47 (10), 2839–2852. 10.1016/j.ultrasmedbio.2021.06.005 [PubMed] [CrossRef] [Google Scholar] [Ref list]
14. Harrison A., Lin S., Pounder N., Mikuni-Takagaki Y. (2016). Mode & mechanism of low-intensity pulsed ultrasound (LIPUS) in fracture repair. Ultrasonics 70, 45–52. 10.1016/j.ultras.2016.03.016 [PubMed] [CrossRef] [Google Scholar] [Ref list]
15. Rabut C., Yoo S., Hurt R. C., Jin Z., Li H., Guo H., et al. (2020). Ultrasound technologies for imaging and modulating neural activity.

Neuron 108 (1), 93–110. 10.1016/j.neuron.2020.09.003 [PMC free article] [PubMed] [CrossRef] [Google Scholar] [Ref list]

16. Lu H., Liu F., Chen H., Chen C., Qu J., Xu D., et al. (2016). The effect of low-intensity pulsed ultrasound on bone-tendon junction healing: Initiating after inflammation stage. J. Orthop. Res. 34 (10), 1697–1706. 10.1002/jor.23180 [PMC free article] [PubMed] [CrossRef] [Google Scholar] [Ref list]
17. Wilkin L. D., Merrick M. A., Kirby T. E., Devor S. T. (2004). Influence of therapeutic ultrasound on skeletal muscle regeneration following blunt contusion. Int. J. Sports Med. 25 (1), 73–77. 10.1055/s-2003-45234 [PubMed] [CrossRef] [Google Scholar] [Ref list]
18. Markert C. D., Merrick M. A., Kirby T. E., Devor S. T. (2005). Nonthermal ultrasound and exercise in skeletal muscle regeneration. Arch. Phys. Med. Rehabil. 86 (7), 1304–1310. 10.1016/j.apmr.2004.12.037 [PubMed] [CrossRef] [Google Scholar] [Ref list]
19. McBrier N. M., Lekan J. M., Druhan L. J., Devor S. T., Merrick M. A. (2007). Therapeutic ultrasound decreases mechano-growth factor messenger ribonucleic acid expression after muscle contusion injury. Arch. Phys. Med. Rehabil. 88 (7), 936–940. 10.1016/j.apmr.2007.04.005 [PubMed] [CrossRef] [Google Scholar] [Ref list]
20. Freitas L. S., Freitas T., Silveira P., Rocha L., Pinho R., Streck E. (2007). Effect of therapeutic pulsed ultrasound on parameters of oxidative stress in skeletal muscle after injury. Cell Biol. Int. 31 (5), 482–488. 10.1016/j.cellbi.2006.11.015 [PubMed] [CrossRef] [Google Scholar] [Ref list]