

The Emerging Era of Interventional Imaging in Rheumatology: An Overview During the Coronavirus Disease-2019 (COVID-19) Pandemic

Adham Aboul Fotouh¹, Mona Hamdy², Fatma Ali², Eman F Mohamed³, Abdallah Allam⁴, Waleed A Hassan⁵, Ahmed Elsaman⁶, Amany El-Najjar⁷, Marwa A Amer⁸, Doaa Mosad⁹, Samar Tharwat¹⁰, Samah A El Bakry¹¹, Hanan Saleh¹², Ahmed Zaghloul¹³, Mostafa Mahmoud¹⁴, Reem HA Mohammed¹⁵, Hanan El-Saadany⁴, Hanan M Fathi¹⁶, Nevin Hammam¹⁷, Hala A Raafat¹⁵, Ashraf N Moharram¹⁴, Tamer A Gheita¹⁵

On behalf of the Egyptian College of Rheumatology (ECR) Musculoskeletal Ultrasound Study Group

¹Cairo University Hospital, Cairo, Egypt; ²Rheumatology Department, Faculty of Medicine, Minia University, Minia, Egypt; ³Internal Medicine Department, Rheumatology Unit, Faculty of Medicine, AlAzhar Girls, Cairo, Egypt; ⁴Rheumatology Department, Faculty of Medicine, Tanta University, Tanta, Egypt; ⁵Rheumatology Department, Faculty of Medicine, Benha University, Banha, Egypt; ⁶Rheumatology Department, Faculty of Medicine, Sohag University, Sohag, Egypt; ⁷Rheumatology Department, Faculty of Medicine, Zagazig University, Zagazig, Egypt; ⁸Rheumatology Department, Faculty of Medicine, Alexandria University, Alexandria, Egypt; ⁹Rheumatology Department, Faculty of Medicine, Mansoura University, Mansoura, Egypt; ¹⁰Internal Medicine Department, Rheumatology Unit, Faculty of Medicine, Mansoura University, Mansoura, Egypt; ¹¹Internal Medicine Department, Rheumatology Unit, Faculty of Medicine, Ain Shams University, Cairo, Egypt; ¹²Rheumatology Department, Faculty of Medicine, Ain Shams University, Cairo, Egypt; ¹³Interventional Pain Management and Anesthesia, Faculty of Medicine, Cairo University, Cairo, Egypt; ¹⁴Orthopedic and Microsurgery, Faculty of Medicine, Cairo University, Cairo, Egypt; ¹⁵Rheumatology and Clinical Immunology Department, Faculty of Medicine, Cairo University, Cairo, Egypt; ¹⁶Rheumatology Department, Faculty of Medicine, Fayoum University, Fayoum, Egypt; ¹⁷Rheumatology Department, Faculty of Medicine, Assiut University, Assiut, Egypt

Correspondence: Tamer A Gheita, Rheumatology and Clinical Immunology Department, Faculty of Medicine, Cairo University, Cairo, Egypt, Tel +20 1004567975, Email gheitam@hotmail.com

Abstract: Imaging has long been taking its place in the diagnosis, monitor, and prognosis of rheumatic diseases. It plays a vital role in the appraisal of treatment. Key progress in the clinical practice of rheumatology is the innovation of advanced imaging modalities; such as musculoskeletal ultrasound (MSUS), computerized tomography (CT) and magnetic resonance imaging (MRI). These modalities introduced a promising noninvasive method for visualizing bone and soft tissues to enable an improved diagnosis. The use of MSUS in rheumatology is considered a landmark in the evolution of the specialty and its ease of use and many applications in rheumatic diseases make it a forerunner instrument in the practice. The use of MSUS among rheumatologists must parallel the development rate of the excellence revealed in the specialty. Moreover, innovative interventional imaging in rheumatology (III-R) is gaining fame and key roles in the near future for a comprehensive management of rheumatic diseases with precision. This review article throws light on the emergence of these robust innovations that may reshape the guidelines and practice in rheumatology, in particular, efforts to enhance best practice during the coronavirus disease 2019 (COVID-19) pandemic are endorsed.

Keywords: interventional imaging, musculoskeletal ultrasound, rheumatology, COVID-19 pandemic

Current Imaging Modalities in Rheumatology

Imaging is playing a fundamental role in the diagnosis, monitor and prognosis of rheumatic diseases. Foremost progress in the clinical practice of rheumatology is fuelled by hi-tech innovations. Although conventional radiography exists as the primary widely used imaging modality by rheumatologists, musculoskeletal ultrasound (MSUS), computerized tomography (CT) and magnetic resonance imaging (MRI) provided a non-invasive modalities with a promising interventional role.¹ Every imaging modality has its pros and cons.² *Conventional radiography* is a primary imaging modality; however,

the limited visualisation significantly limits its utility.³ In the precedent years, the use of US are considered landmarks in the evolution of the specialty. Its accessibility and numerous applications in rheumatic diseases make it a forerunner modality in clinical practice and many rheumatologists consider it the optimum “extension” of medical assessment.⁴ MSUS imaging allows detecting inflammation of the joint cavity, tendons and bursae, as well as activity assessment.⁵ This is now apparent by numerous inclusions in European League Against Rheumatism (EULAR) and American College of Rheumatology (ACR) classification criteria for rheumatoid arthritis (RA), crystal-induced arthritis, spondyloarthritis (SpA), or polymyalgia rheumatic (PMR).⁶ *Computed tomography* can ultimately evaluate cartilage degeneration by three dimensions visualization of joint space narrowing as direct observation is possible by the invasive injection of a contrast material. *Dual-energy CT* helps in the identification of crystals thus refining the differential diagnosis of undifferentiated arthritis.⁷ *MRI* permits timely classification of axial SpA (axSpA) ahead of structural damage. MRI has served in expanding the knowledge regarding the pathophysiology, untimely diagnosis, prognosis, therapeutic effectiveness of enthesitis.⁸ In daily clinical practice, MRI is the leading non-invasive imaging modality to evaluate early structural variations in the cartilage volume or thickness,⁹ and surrounding tissues.³ Whole-body MRI is gaining more value in the diagnosis, prognosis and therapeutic response assessment in the pediatric rheumatic diseases.¹⁰ However, MSUS is not regularly considered as the primary imaging technique in the estimation of suspicious axSpA.¹¹ The rising *hybrid imaging*, PET/MRI and *single photon emission CT* (SPECT)/CT, paves way for a potentially enhanced ability to concurrently assess the joint's structural change and functional activity in osteoarthritis (OA) research.³ Provided the central contribution of imaging in the appraisal of therapy, in certain situations, more than one modality may be required.¹² Alongside with *CT*, *MRI* allows differentiation of doubtful sacroiliitis and degeneration of the spine, and *positron emission tomography* (PET) was chiefly requested to settle a diagnosis of large-vessels vasculitis.¹³

Diagnostic Potential of Imaging Modalities in Rheumatology Inflammatory Arthritis

In spite being well-established imaging tools, US and MRI have been lately integrated into essential Rheumatology practice. Both surpass conventional radiography in the detection of bone erosions as they are ever more being utilized for the detection of subclinical inflammation in patients with arthritis. On performing sequential evaluation of synovitis, US or MRI imaging may be considered as a lively biomarker that could monitor the evolution of the disease and the therapeutic implications.¹ Both can enable predicting the progress of undifferentiated arthritis to erosive RA.¹⁴ MSUS plays a vital role in the detecting subclinical synovitis especially for those in clinical remission. Moreover, the significance of US in the diagnosis and monitoring of peripheral SpA is gaining popularity.⁵ Power Doppler (PD) signal of the synovial membrane has prognostic value for RA.⁷ The use of US with PD helps differentiate between active and inactive inflammation within joints and periarticular soft tissues thus allowing more accurate and objective assessment.¹⁵ Together the rheumatologist and radiologist should make the most of these developments in view of the recent recommendations from EULAR that offer helpful guidance.¹⁶

Enthesitis and Dactylitis

Clinical and US *enthesitis* scores were reported to be comparable in AxSpA.¹⁷ Creating a sonographic enthesitis scoring system is an imperative step in enhancing a brisk diagnosis and in promoting early interventions that may broadly improve enduring outcomes.¹⁸ In addition, imaging also helps in sorting out the primary pathogenesis pathways that may lead to the chronicity of *dactylitis* in PsA patients.¹⁹ DACTylitis gLObal Sonographic (DACTOS) score is a consistent measure to understand the US characteristics of dactylitis and supports clinical diagnosis and management in PsA patients with dactylitis.²⁰

Vasculitis

Ultrasound more commonly determines large-vessel vasculitis compared to contrast-enhanced MRA. This has supported the recommendation that US is a leading step in the appraisal of giant cell arteritis (GCA).²¹ In the latest PMR criteria, an US scan of the shoulder and pelvis regions was a reliable substitute to clinical assessment.²²

Sjögren's Syndrome

Salivary gland US (SGUS) has lately been re-discovered as a promising measure to evaluate salivary gland involvement in primary Sjögren's syndrome (SS) with added value in disease stratification and monitoring patient response to therapy.²³ With confidence, SGUS as a noninvasive modality provides a high diagnostic yield for both primary and secondary SS.²⁴

Myositis

There is an emerging useful role of US in the evaluation of myositis.^{25,26} Sonoelastography is currently applied in the diagnosis of myositis and become a regular handy additional technique.²⁷ Patients with inclusion body myositis (IBM) have a noticeable increase in echogenic intensity of the muscles due to fatty substitution. Most prominently, US revealed a notable precision in contrast to MRI.²⁸ As there are no unambiguous guidelines for using of diagnostic US for the assessment of idiopathic inflammatory myositis (IIM), it was reported that edema and PD are firmly associated with early myositis and the degree of activity as inflamed muscles appear swollen, thickened and with PD signals. The aforementioned provides a window of hope for a novel potential role of US in the diagnosis and monitoring of IIM.²⁹ Certainly, US may be regarded as a promising tool and outcome measure in autoimmune myositis (AIM).³⁰

Systemic Sclerosis

There is a rising handy role of US in the estimation of scleroderma.²⁵ In juvenile systemic sclerosis (SSc), US provides real-time lively high-resolution images and with the aid of advanced transducers, it allows notable cutaneous and articular imaging. B-mode or PD may show thickening and hypervascularization of the skin and subcutaneous tissue, synovitis, tenosynovitis, and small calcific deposits. MRI provides added value in the assessment of cutaneous inflammation and atrophy as well as the deeper structures such as the fascia, muscles and joints that could be difficult to see on US. However, in children MRI may necessitate sedation in addition to being costly and time-consuming. Conventional radiography may show soft-tissue calcification, acroosteolysis, contractures, and subluxations. As CT warrants a high-dose of radiation, it is usually avoided in children.³¹ Using US to identify skin ulcers in scleroderma patients has been validated and showed a promising result to characterize the morphology and detect underlying pathology of skin ulcers.³² ACR/EULAR classification criteria allow for the US features for the hand to replace capillaroscopy with a comparable performance in their diagnostic potential in SSc.³³

Pediatric Rheumatism

There is emerging proof in favor of using MSUS in the estimation and management of children with rheumatic diseases with special focus on juvenile idiopathic arthritis (JIA). MSUS improves the diagnosis of inflammatory joint disease involving synovitis, enthesitis and tenosynovitis as well as the likely discovery of subclinical synovitis.²⁵

Sport Injuries

Interestingly, signal intensity and echogenicity of the knee ligaments on MRI and US were comparable to the histological findings.³⁴ US plays a vital role in the evaluation of sports injuries.³⁵

Peripheral Nerve Disorders

Neuromuscular US (NMUS) is frequently applied to evaluate the peripheral nerves of the lower limbs due to its superiority over MRI in showing the soft-tissue details at a reduced price besides avoiding magnetic artifacts and being user friendly with greater sensitivity. Further reimbursements are the ability of real-time dynamic imaging, and the prompt capacity to visualize the upper and lower limbs on both sides. It may also guide diagnosis and management strategies.³⁶ Using combined US parameters in association with nerve conduction studies (NCS) and nerve histopathology are highly suggested to further look into systemic lupus erythematosus (SLE) neuropathy.³⁷

Interventional Imaging in Rheumatology (III-R)

The spectrum of utilizing interventional imaging in Rheumatology is presented in Figure 1 and the various regions approached in Figure 2. The Egyptian Rheumatologists experience with interventional imaging using MSUS in various articular regions is presented in Figure 3.

Articular-Ultrasound-Guided (USG) Injection

Ultrasound-guided *temporo-mandibular joint* (TMJ) injections are performed with high proficiency compared to the conventional blind technique, in particular on targeting the lower joint space.³⁸ Intra-articular injection of the *zygo-apophyseal (facet) joint* is a recognized diagnostic approach of the cervical spine and US-guided technique adds to its accuracy.³⁹

US-guided injection of the *shoulder* proved effective regardless the procedure for injection (anterior, posterior, or lateral) and was effective for post-injection evaluation.⁴⁰ US-guided injection of the shoulder via the rotator interval technique is used for arthrograms, and intra-articular shoulder joint injections.⁴¹ US-guided steroid injection procedure provides a dramatic improvement. When hyaluronic acid (HA) is considered, a more targeted site should be well-thought out to enhance the efficacy and prevent side effects.⁴²

Currently, US imaging is a key modality used to promptly improve the diagnosis of *Elbow* pain and guide interventions in its management.⁴³ US-guided injection of the elbow joint; radio-ulnar and radio-humeral with corticosteroid eliminated any enduring pain and remarkably optimized the range of motion.

Intra-articular HA is generally required in the management of symptomatic OA of the thumb *carpometacarpal joint* and US-guided injection was found to be effective and safe.⁴⁴ US may be used to accurately perform intra-articular *trapeziometacarpal* (TMC) joint injections. Moreover, US is a feasible substitute of fluoroscopy when a targeted injection is needed.⁴⁵ Amazingly, US-guided intra-articular injection of anti-tumor necrosis factor alpha (anti TNF- α) in small joints with arthritis involving the wrists, and finger joints gave no noticeable adverse events.⁴⁶ Furthermore, US-guided dry needling secured a significant advance of shoulder and hand movements in cases of complex regional pain syndrome (CRPS).⁴⁷

Intra-articular injection is commonly acquired for *hip* joint diseases and provides a valuable therapeutic option.⁴⁸ US-guided intra-articular injection has become a basic choice in the diagnosis and treatment of a variety of hip disorders. US provides sizeable therapeutic importance particularly when considered in combination with a sufficient physical therapy program.⁴⁹ US-guided intra-articular injection of HA was found effective and safe in the treatment of symptomatic hip OA.⁵⁰

Besides the famous treatment options for *knee* OA such as HA, corticosteroids and oxygen-ozone therapy, many other promising products have been employed in the last decades such as polydeoxy-ribonucleotide, platelet-rich plasma (PRP) and mesenchymal stem cells (MSCs). Also, US-guided intra-meniscal injection has been launched into clinical practice. The use of biologic therapy and monoclonal antibodies involving nano-molecular technology are presently evolving with

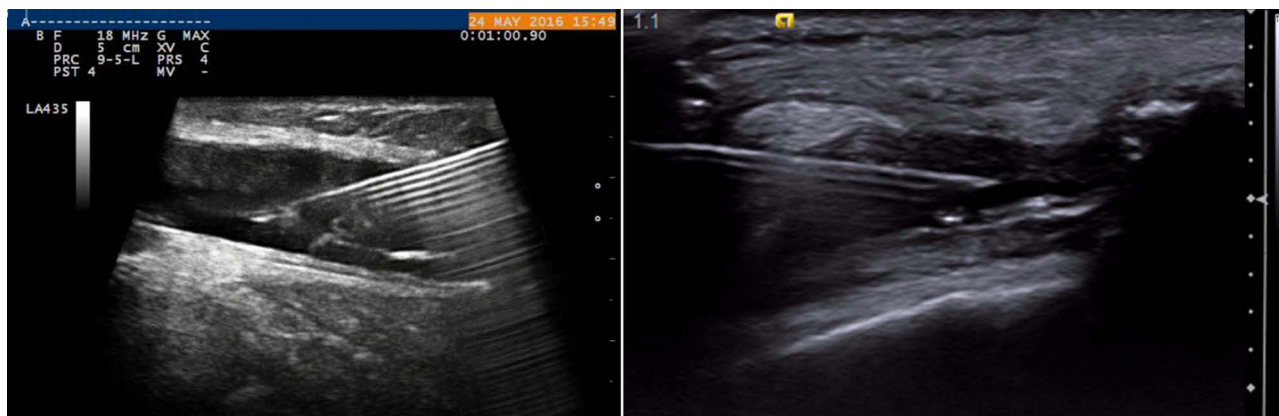


Figure 1 Spectrum of the role of interventional imaging in rheumatology.

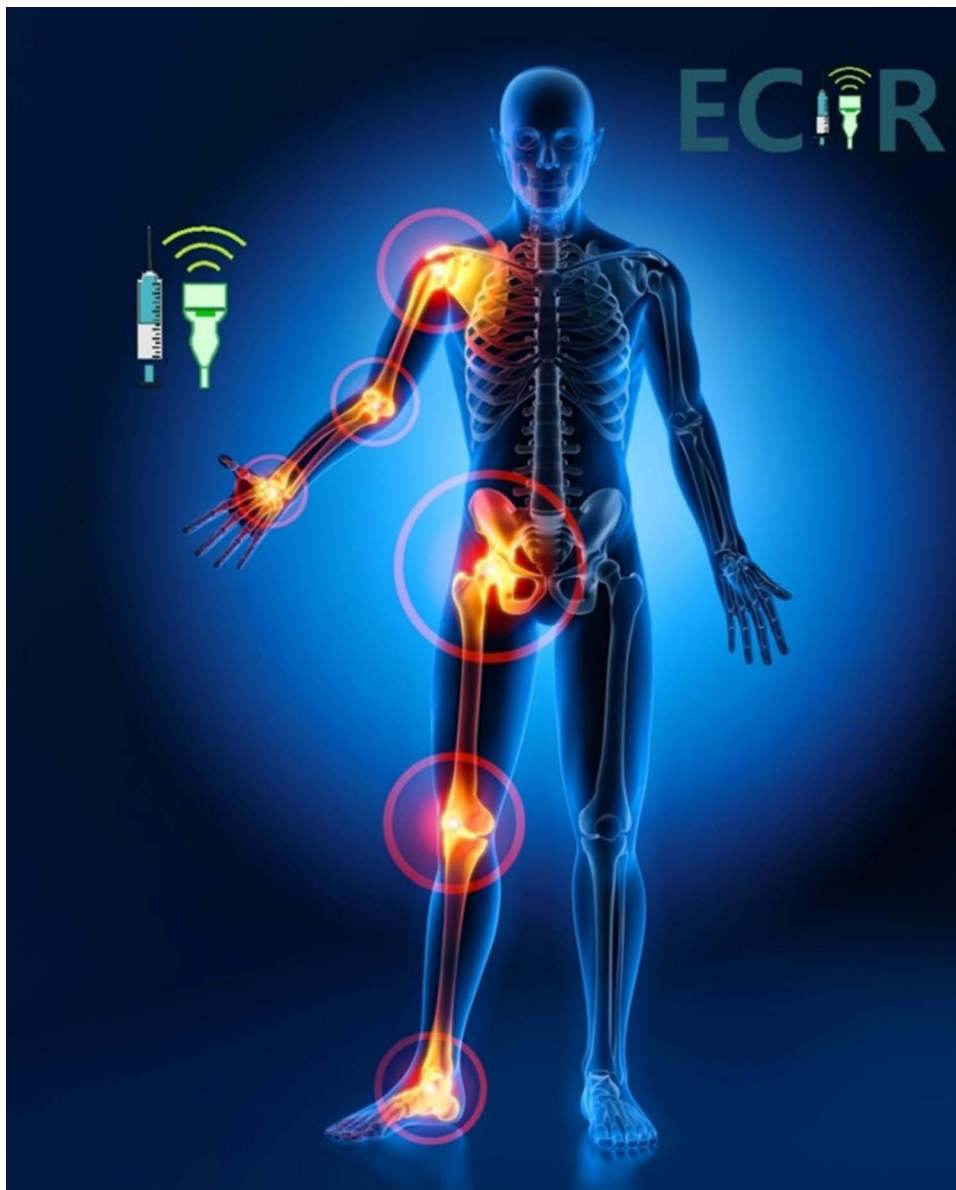


Figure 2 Musculoskeletal regions considered in ultrasound-guided interventional injections.

the aim of establishing personalized medicine and mounting the therapeutic armamentarium against knee OA.⁵¹ As knee structures are mostly superficial and the ease of access, an outstanding visualization could be facilitated with a high-frequency linear array transducer. In most cases, an in-plane way is simply attained. US-guided knee approaches have constantly shown superior correctness, especially for patients with a high body mass index and allows a more specific diagnosis and accurate targeting of the lesions with satisfactory safety.⁵²

US-guided injection of the *foot and ankle* helps in the alleviation of pain due to disorders related to the joints, bursae, tendons, and nerves at an improved accuracy to provide a solid diagnosis with reasonable safety particularly when done close to neurovascular structures.⁵³ Interestingly, among patients with *ankle* OA, USG intra-articular PRP injection was akin USG placebo injection as regards pain and disability.⁵⁴ US guided injection of the *talonavicular joint* is better compared to a LMB method.⁵⁵ US guided posterior *subtalar joint* injections allow easy and precise needle insertion while reducing the risk of damaging nearby vital soft-tissues structures un-noticed by other procedures such as fluoroscopy or CT.⁵⁶ However, LMB approach is as effective as US-guidance for intra-articular injection in patients with hallux rigidus.⁵⁷

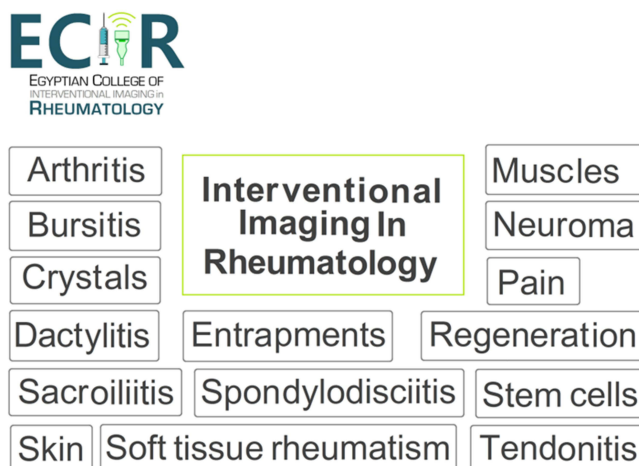


Figure 3 Musculoskeletal ultrasound (MSUS) interventional imaging of the suprapatellar space (transverse and longitudinal views B mode) with in-plane ultrasound guided needle.

Articular-Ultrasound-Guided (USG) Aspiration

USG arthrocentesis is adding great compensation over a blind landmark-based (LMB) approach. USG arthrocentesis offers direct visualization of the effusion and is performed with high precision and limited attempts. It can also determine mild effusions that would not be evaluated using a LMB approach.⁵⁸ In patients with knee pain due to OA and meniscal tear, US-guided micro-fragmented fat tissue injected into a torn meniscus was reported to be a secure and likely successful preference.⁵⁹ Knee OA treated with USG intra-articular injection of bone marrow concentrate lead to a considerable improvement in symptoms and functional status with minimal complications.⁶⁰

Articular-Ultrasound-Guided (USG) Biopsy

US-guided knee intra-articular *core needle biopsy* in patients with possible soft-tissue tumours is a highly effective and safe technique.⁶¹ In addition to being efficient, secure and nonradioactive, US allows easy guidance for radiofrequency (RF) in symptomatic relief and functional upgrading in knee OA patients.⁶² Moreover, US-guided genicular nerve cooled RF ablation provides a finer efficacy in the management of non-surgically indicated patients with advanced knee OA.⁶³ Amusingly, USG knee procedures were related to more patient satisfaction, immediately and after 4–6 weeks compared to LMB approach.⁶⁴

Soft Tissue and Regional Rheumatism–USG Injection

Tendinopathy

Percutaneous tenotomy is a needle is repeatedly inserted into the abnormal tendon with the aim of switching a chronic degenerative process to an acute inflammatory condition that may proceed towards tendon healing. US guidance for this procedure is indispensable to make sure that the damaged part of the tendon is precisely targeted.⁶⁵ Moreover, progress in stem-cell technology offers a novel opportunity in regenerative rheumatology.¹

Dactylitis

The effectiveness of US-guided steroid injection for dactylitis has been well-known with the remarkable remission and improvement in extra-articular inflammation with special reference to tenosynovitis and soft tissue oedema.⁶⁶

Subcutaneous Lesions

The calcific deposits in SSc can lead to functional restrictions, cutaneous ulcers and cosmetic deformities. Management of *calcific deposits* can be difficult and refractory to surgical and non-surgical treatment options. *US-guided aspiration* was reported to be useful in treatment of such conditions.⁶⁷

Muscle Injury

PRP is a compelling mini-invasive treatment for *muscle injuries*, and to maximize its efficacy US guidance accurately localizes the lesion and leads the needle enabling full muscle recovery.⁶⁸ US-guided intramuscular injection can be carried out with excellent accuracy in the *sternocleidomastoid muscle* in patients with *cervical dystonia*, as US can be used to evaluate the muscle thickness and cross-sectional area.⁶⁹

Shoulder Region

Ultrasound is effectual in localizing the needle insertion into the *subacromial bursa* in patients with chronic subacromial bursitis.⁷⁰

Elbow Region

US-guided injection is of value in treating *olecranon bursitis*.⁷¹ In cases of *chronic elbow tendonopathies*, US-guided PRP injection was within the tendon in all cases.⁷²

Wrist Region

US-guided one injection of PRP, can improve the clinical symptoms of patients with a mild to moderate *carpal tunnel syndrome* (CTS).⁷³

Hand Region

US-guided injection of steroid and HA could be a reasonable and easy mode for the treatment of *trigger finger*;⁷⁴ however, it has been reported that it may be time consuming with more effort and similar clinical benefits compared to the blinded LMB technique.⁷⁵ US-guided Dupuytren's contracture injection tended to be superior than standard injections.⁷⁶

Lower Back

Interventional *lower back facet joint* management with US-guided oxygen/ozone therapy was considered safe and effective.⁷⁷

Pelvis, hip and thigh region: US-guided technique allows accurate guidance for the injection of botulinum toxin in the management of *iliopsoas spasticity*⁷⁸ and *greater trochanteric* pain was effectively managed by US-guided injection.⁷⁹ US-guidance is relatively more expensive and anatomic LMB injection continues to be the method of choice for *trochanteric bursitis* and US-guided approach is reserved for extreme obesity or injection failure.⁸⁰ However, treatment of *meralgia paresthetica* with US-guided injection was comparable to surgery.⁸¹

Knee Region

US-guided *pes anserinus bursa* injection is more precise and efficient than blind LMB injection.⁸² The contemporaneous administration of PRP and high volume US-guided injections of saline influences *tendon repair* by means of various mechanisms and grant a superior enhancement for patellar tendinopathy.⁸³ Interestingly, *intraalipolysis* is an effective method for decreasing fat deposits on the inner side of the knees. Ultrasonography is confirmed to be a valuable method to check the proper administration of the medication and to assess outcomes.⁸⁴

Foot Region

The need for interventional US-guidance is a well-known procedure and aids in the guidance for vascular and visceral structures. MSUS for the foot and ankle provides focused insertion of the needle tip and consequent injection. US-guided injection is considered an effective procedure for diagnostic aspiration of the joint, tendon, and bursae.⁸⁵ Both US-guided botulinum toxin and steroid injection were effective in the treatment of *plantar fasciitis*.⁸⁶ Injection of *Morton neuroma* under US guidance provides a significant improvement compared to blind injection.⁸⁷

Guidelines for Best Practice During the Coronavirus Disease-2019 (COVID-19) Pandemic

The current coronavirus disease-2019 pandemic has strained medical resources, generating a dilemma for physicians responsible to limit spread of the infection and to treat the patients they are entrusted to care for.⁸⁸ The challenges of the

COVID-19 pandemic exposed many limitations to treatment access and medication adherence in rheumatic diseases patients and accelerated changes in the way we convey health-care.⁸⁹ Intra-articular injections are allowed when there is no practical therapeutic options, and provided that safety measures to protect the patient and the rheumatologist from viral contamination are followed and suitable information is provided to the patient.⁹⁰ The global mass production of vaccines against COVID-19 is highly encouraged by the Rheumatology university staff members for the rheumatic diseases patients once available.⁹¹ Fortunately, the rheumatic diseases patients reported side effects were typical of those reported in the general population and the relatively reduced frequency of rheumatic disease flare necessitating medications was reassuring.⁹²

In acknowledgment, many rheumatic diseases patients demanding an interventional imaging maneuver during the COVID-19 pandemic are higher risk groups. Telemedicine may provide an effective platform for new and established patients' appointments. Post-intervention follow-up would also be more suitable and convenient if teleMedicine is applied. Nonetheless, provided their very low risks, the lack of appropriate substitutes, and the other benefits afforded by physical and psychological therapies in times of crisis, it is recommended that telehealth be used whenever feasible if indicated.

The COVID-19 pandemic has encouraged everyone to update the standard medical procedures and adapt them to this new era that may involve using wireless probes for US-guided procedures; as they are easier to carry and clean.⁹³ Best practice guidelines for III-R should consider the following:

General Measures for COVID-19 Infection Risk Alleviation

General infection control precautions form the basis of interventional-imaging (injections) practices. In harmony with the Centers for Disease Control and Prevention (CDC) infection control recommendations for preventing transmission, the recommendations that are most applicable to interventional-imaging rheumatologists and their patients include those presented in [Table 1](#).

Table 1 General Measures for Corona Virus Disease 2019 (COVID-19) Infection Risk Alleviation During Interventional-Imaging in Rheumatology

General Measures for COVID-19 Infection Risk Alleviation	
1	Placing signs to educate patients on proper hand and respiratory hygiene as well as cough etiquette.
2	Providing sufficient supplies in noticeable and reachable places.
3	Triage patients with fever and or respiratory symptoms and enforce the use of a facemask
4	Limit unnecessary patient escorts.
5	Adequately separating patients ideally 2 meters (6.5 feet) apart in waiting rooms, locations and queues.
6	Patients should be met in hygienic and satisfactorily disinfected rooms, with no previous exposure to COVID-19 patients.
7	Hand hygiene with 60–95% alcohol-based hand rub for 15 seconds or with soap/water for 20 seconds before and between all patient care episodes.
8	Robustly ensure using face masks and wearing gloves during any patient interaction and care.
9	In areas with community spread, use scrubs before seeing patients.
10	Avoid touching the patients face.
11	During procedures, sterile disposable sheets should be used for each patient.
12	Sterilize and disinfect all surfaces in the patient's care surroundings including the tables, beds, chairs, door handles and equipments between each patient visit.
13	Ensure sufficient sleep and hydration.
14	Optimize health and boost the immune system via behavioral changes such as quitting smoking, improvements in diet and exercise.

Specific Interventional-Imaging Measures for COVID-19 Infection Risk Alleviation

For procedures or consultations that need to be performed in high risk patients or those known to be infectious, the extra measures presented in Table 2 should be considered.

Even though the aforementioned guidelines provides a framework for interventional-imaging management services for rheumatic diseases patients, the clinical status of the patient must be well thought-out in view of the regional health settings, government and hospital directives, resource accessibility, as well as the wellbeing of health-care providers.

Special Emphasis

Interventional Rheumatology: Crosstalk with Other Specialties

The past decade has brought a fresh raft of high-tech progress that has encouraged physicians to cross-examine and manage rheumatic diseases with rising complexity.¹ Well organized and focused US protocols for basic clinical queries have been constructed and put into practice of the following medical fields: anesthesia, cardiovascular, critical-care, dermatology, emergency, neonatal care, gynecological, rheumatology and more in the queue. Point of Care (POC) US is user dependent and needs quality assurance, proper education and sensible training. POC US has the capability to become the physician's innovative special global examination procedure.

US-guided injections in pain Medicine are accepted procedure for pain interventions.⁹⁴ Experience of *anesthesiologists* with USG intra-articular knee injection demonstrated that knee flexion provides another approach that may improve the scan of the suprapatellar bursa when compared to knee extension.⁹⁵ Furthermore, anesthesiologists consider that US is useful for procedures of the ankle joint and adjacent structures.⁹⁴

Radiosynoviorthesis using the intra-articular intervention of β -particle emitting radiocolloids has for years been used for the confined management of inflammatory joint diseases. The European Association of *Nuclear Medicine* (EANM) in close association with an international team of clinical experts, including rheumatologists, provided guidelines.⁹⁶ The European Society of *Musculoskeletal Radiology* (ESSR) primed recommendations about the role of US in diagnosing musculoskeletal

Table 2 Specific Measures for Corona Virus Disease 2019 (COVID-19) Infection Risk Alleviation During Interventional-Imaging in Rheumatology

	Specific Measure for COVID-19 Infection Risk Alleviation
1	Face mask and better if N95 should be used to protect against droplet transmission.
2	Wear cleanable face shields over the mask (when possible).
3	Appropriate use of personal protective equipment (PPE)
4	Wash hands/use gloves before doffing and donning equipments.
5	Properly store, sterilize and disinfect equipments between uses.
6	Minimize the exposure time, limit and sterilize the body regions exposed.
7	Similar to open surgical procedures, the patients may be requested to shower before receiving injections in high-risk circumstances.
8	Procedures should be performed with the minimal number of personnel to avoid or diminish "unnecessary" exposure of hospital staff to patients and identify specific roles that can be carried out remotely. Only those fundamental to the physician-patient interaction should be permitted to enter the hospital and patient care sites.
9	Follow-up cases do not typically require a complete physical examination.
10	Visually inspect body fluids or damage.
11	Except in demanding circumstances, deep sedation that may necessitate airway support should be avoided.

diseases. US was considered the method of choice in imaging peripheral synovitis.⁵ Furthermore, US-imaging is gaining fame thanks to the last classification criteria for RA issued by the ACR and EULAR in 2010.⁹⁷

Interventional Rheumatologists: Crosstalk with Other Specialists

The reported frequency of rheumatologists performing US was widely varied across member countries of the EULAR, ranging from >80% in 6% of countries to <10% in 15% of countries. Most experts mention that their national rheumatology societies arrange MSUS workshops, while courses in MRI or CT were less commonly reported.⁹⁸

Egyptian society of musculoskeletal and neuromuscular sonography (ESMNS)⁹⁹ based in Minia governorate has been developed and enforced in 2019. In collaboration with the Arab league of musculoskeletal, neuromuscular and spine ultrasound (ALMNSU), and as a promising step, the 1st hybrid international conference was held in Cairo, Egypt (1st–2nd Dec. 2021) on musculoskeletal, neuromuscular and spine ultrasound in rheumatology in close collaboration with colleagues in the fields of radiodiagnosis, anesthesia and pain management as well as orthopedic surgery. The conference included many hands-on workshops in order to affirm the ongoing continuous educational role, as well as the illustrated lectures on the emerging importance of interventional imaging in rheumatology (III-R). Among the ESMNS objectives was the development of a consensus-based comprehensive and practical framework on standardized procedures for MSUS imaging in rheumatology in Egypt in agreement with the EULAR standardized protocols for US imaging.⁶ Moreover, the conference call was compelling to determine the need for interventional-imaging management guidelines for the rheumatic diseases patients during the coronavirus disease-2019 (COVID-19) pandemic. Currently in Egypt there are around 100 trained rheumatologist ultrasonographers with various grades of skills and 50 of them with an international base and around 10 are EULAR certified MSUS trainers.

The New Portable US

Current and future progress in medical ultrasound have made the tool extensively pertinent and the new cart-based and pocket size devices have allowed for applicable POC US examinations in various medical specialties. It is promptly executed as a real-time measure helping the physician in diagnosis and needle guidance for percutaneous procedures. The procedure can be performed bedside or at any location that the patient may be present.¹⁰⁰

On comparing POC to the conventional cart-based US machine, a musculoskeletal diagnosis using portable hand-held US was equivalent in spite the limitations. Improvement in the equipment and technology may allow widespread consideration in the near future.¹⁰¹

Conclusion

In conclusion, imaging modalities, in particular, MSUS provided their expanding role in rheumatology. The application of interventional imaging in the daily clinical practice of rheumatology seems inevitable and a closely reachable goal. The proposed overview aimed to help interventional rheumatologists perform the best and safest practice during these hard times. The current manuscript is intended to serve as a foundation for continued dialogue on best practices. Such task may be considered in collaboration with the Egyptian College of Rheumatology (ECR) that has been working on presenting the national spectrum of rheumatic diseases since 2017 and calls for the emergence of the “Egyptian College of Interventional Imaging in Rheumatology” in order to narrow the gap among rheumatologists in easy dealing with imaging tools and in making US a crucial component of daily routine practice.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

Disclosure

The authors report no conflicts of interest for this work.

References

1. Robinson WH, Mao R. Decade in review-technology: technological advances transforming rheumatology. *Nat Rev Rheumatol.* 2015;11(11):626–628. doi:10.1038/nrrheum.2015.137
2. Möller I, Janta I, Backhaus M, et al. The 2017 EULAR standardised procedures for ultrasound imaging in rheumatology. *Ann Rheum Dis.* 2017;76:1974–1979. doi:10.1136/annrheumdis-2017-211585
3. Hayashi D, Roemer FW, Guermazi A. Recent advances in research imaging of osteoarthritis with focus on MRI, ultrasound and hybrid imaging. *Clin Exp Rheumatol.* 2018;36 Suppl 114(5):43–52.
4. Mandl P, Ciechomska A, Terslev L, et al. Implementation and role of modern musculoskeletal imaging in rheumatological practice in member countries of EULAR. *RMD Open.* 2019;5(2):e000950. doi:10.1136/rmdopen-2019-000950
5. Plaza M, Nowakowska-Plaza A, Pracon G, Sudol-Szopińska I. Role of ultrasonography in the diagnosis of rheumatic diseases in light of ACR/EULAR guidelines. *J Ultrason.* 2016;16(64):55–64. doi:10.15557/JoU.2016.0006
6. Millet JD, Brown RK, Levi B, et al. Frostbite: spectrum of Imaging Findings and Guidelines for Management. *Radiographics.* 2016;36(7):2154–2169. doi:10.1148/rg.2016160045
7. Ritchlin C, Adamopoulos IE. Axial spondyloarthritis: new advances in diagnosis and management. *BMJ.* 2021;372:m4447. doi:10.1136/bmj.m4447
8. Mathew AJ, Østergaard M. Magnetic resonance imaging of enthesitis in spondyloarthritis, including psoriatic arthritis-status and recent advances. *Front Med.* 2020;7:296. doi:10.3389/fmed.2020.00296
9. Mohammadinejad R, Ashrafzadeh M, Pardakhty A, et al. Nanotechnological Strategies for Osteoarthritis Diagnosis, Monitoring, Clinical Management, and Regenerative Medicine: recent Advances and Future Opportunities. *Curr Rheumatol Rep.* 2020;22(4):12.
10. Deplano L, Piga M, Porcu M, et al. Whole-Body MRI in Rheumatology: major Advances and Future Perspectives. *Diagnostics.* 2021;11(10):1770. doi:10.3390/diagnostics11101770
11. Czuczman GJ, Mandell JC, Wessell DE, et al.; Expert Panel on Musculoskeletal Imaging. ACR Appropriateness Criteria® Inflammatory Back Pain: known or Suspected Axial Spondyloarthritis: 2021 Update. *J Am Coll Radiol.* 2021;18(11S):S340–S360. doi:10.1016/j.jacr.2021.08.003
12. Sullivan J, Pillinger MH, Toprover M. Chondrocalcinosis: advances in Diagnostic Imaging. *Curr Rheumatol Rep.* 2021;23(10):77. doi:10.1007/s11926-021-01044-4
13. Almeida DE, Costa E, Cerqueira M. Advances in Ultrasound Imaging in Rheumatology-What Do they Mean and What Challenges Do they Pose? The Example of Microvascular Imaging. *J Ultrasound Med.* 2021;41(3):785–787. doi:10.1002/jum.15754
14. Østergaard M. Clarification of the role of ultrasonography, magnetic resonance imaging and conventional radiography in the ACR/EULAR 2010 rheumatoid arthritis classification criteria - comment to the article by Aletaha et al. *Ann Rheum Dis.* 2010;1:433.
15. Florescu A, Pădureanu V, Florescu DN, et al. The Role of Clinical and Ultrasound Enthesitis Scores in Ankylosing Spondylitis. *Life (Basel).* 2021;11(3):218. doi:10.3390/life11030218
16. Eder L, Kaeley GS, Aydin SZ. Development and Validation of a Sonographic Enthesitis Instrument in Psoriatic Arthritis: the GRAPPA Diagnostic Ultrasound Enthesitis Tool (DUET) Project. *J Rheumatol Suppl.* 2020;96:50–52. doi:10.3899/jrheum.200128
17. Girolimetto N, Macchioni P, Tinazzi I, et al. Ultrasound Effectiveness of Steroid Injection for hand Psoriatic Dactylitis: results from a Longitudinal Observational Study. *Rheumatol Ther.* 2021;8(4):1809–1826. doi:10.1007/s40744-021-00383-z
18. Girolimetto N, Giovannini I, Crepaldi G, et al. Psoriatic Dactylitis: current Perspectives and New Insights in Ultrasonography and Magnetic Resonance Imaging. *J Clin Med.* 2021;10(12):2604. doi:10.3390/jcm10122604
19. Kim BS, Kim DS, Kang S, et al. Ultrasound-Guided Injection of the Sternocleidomastoid Muscle: a Cadaveric Study with Implications for Chemodenervation. *PM R.* 2021;13(5):503–509. doi:10.1002/pmrj.12463
20. Zabotti A, Sakellariou G, Tinazzi I, et al. Novel and reliable DACTylitis gObal Sonographic (DACTOS) score in psoriatic arthritis. *Ann Rheum Dis.* 2020;79(8):1037–1043. doi:10.1136/annrheumdis-2020-217191
21. Yip A, Jernberg ET, Bardi M, et al. Magnetic resonance imaging compared to ultrasonography in giant cell arteritis: a cross-sectional study. *Arthritis Res Ther.* 2020;22(1):247. doi:10.1186/s13075-020-02335-4
22. Dasgupta B, Cimmino MA, Kremers HM, et al. 2012 Provisional classification criteria for polymyalgia rheumatica: a European League Against Rheumatism/American College of Rheumatology collaborative initiative. *Arthritis Rheum.* 2012;64(4):943–954. doi:10.1002/art.34356
23. Luciano N, Ferro F, Bombardieri S, Baldini C. Advances in salivary gland ultrasonography in primary Sjögren’s syndrome. *Clin Exp Rheumatol.* 2018;36 Suppl 114(5):159–164.
24. Abd-Allah NM, Omar G, Elameen N, Mousa RA. Diagnostic value of salivary gland ultrasonography for Sjögren’s syndrome in patients with sicca symptoms. *Egyptian Rheumatologist.* 2018;40(3):191–195. doi:10.1016/j.ejr.2017.09.003
25. Vega-Fernandez P, Ting TV, Pratt L, Bacha CM, Oberle EJ. Ultrasonography in pediatric rheumatology. *Rheum Dis Clin North Am.* 2022;48(1):217–231. doi:10.1016/j.rdc.2021.09.009
26. Ewing B, Thomas R, Elsinghorst H, Abdul-Aziz R. Atypical power Doppler ultrasound findings in juvenile idiopathic inflammatory myositis (JIIM) flare. *Cureus.* 2021;13(5):e14949. doi:10.7759/cureus.14949
27. Ekşioğlu AS, Akca Çağlar A, Kaynak Şahap S, Karacan CD, Tuygun N. Value of strain-wave sonoelastography as an imaging modality in the assessment of benign acute myositis in children. *Turk J Med Sci.* 2021;51(6):2951–2958. doi:10.3906/sag-2103-290
28. Guimaraes JB, Cavalcante WCP, Cruz IAN, et al. Musculoskeletal ultrasound in inclusion body myositis: a comparative study with magnetic resonance imaging. *Ultrasound Med Biol.* 2021;47(8):2186–2192. doi:10.1016/j.ultrasmedbio.2021.04.019
29. Conticini E, Falsetti P, Al Khayyat SG, et al. A novel grey Scale and Power Doppler ultrasonographic score for idiopathic inflammatory myopathies: Siena myositis Ultrasound grading scale. *Rheumatology.* 2021;2:keab340.
30. Paramalingam S, Morgan K, Becce F, et al. Conventional ultrasound and elastography as imaging outcome tools in autoimmune myositis: a systematic review by the OMERACT ultrasound group. *Semin Arthritis Rheum.* 2021;51(3):661–676. doi:10.1016/j.semarthrit.2020.11.001
31. Idzior M, Sotniczuk M, Michalski E, Gietka P, Sudol-Szopińska I. Ultrasonography, MRI and classic radiography of skin and MSK involvement in juvenile scleroderma. *J Ultrason.* 2021;20(83):e311–e7. doi:10.15557/JoU.2020.0054
32. de Saint Riquier M, Ballerie A, Robin F, et al. Hand ultrasound for the diagnosis of scleroderma: a scoring strategy including US items and items from the EULAR/ACR classification. *Clin Exp Rheumatol.* 2020;38 Suppl 125(3):140–147.

33. Suliman YA, Kafaja S, Fitzgerald J, et al. Ultrasound characterization of cutaneous ulcers in systemic sclerosis. *Clin Rheumatol.* 2018;37(6):1555–1561. doi:10.1007/s10067-018-3986-5
34. Falkowski AL, Jacobson JA, Gandikota G, Lucas DR, Magerkurth O, Zaotini F. Imaging Characteristics of the Proximal Lateral Collateral Ligament of the Knee: findings on Ultrasound and MRI with Histologic Correlation. *J Ultrasound Med.* 2021;41(4):827–834. doi:10.1002/jum.15761
35. Allen GM, Jacobson JA. Ultrasonography: sports Injuries. In: Hodler J, Kubik-Huch RA, von Schulthess GK, editors. *Musculoskeletal Diseases 2021-2024: Diagnostic Imaging [Internet]*. Cham (CH): Springer; 2021.
36. Yablon CM, Hammer MR, Morag Y, Brandon CJ, Fessell DP, Jacobson JA. US of the Peripheral Nerves of the Lower Extremity: a Landmark Approach. *Radiographics.* 2016;36(2):464–478. doi:10.1148/rg.2016150120
37. Mahran SA, Galluccio F, Khedr TM, et al. Peripheral neuropathy in systemic lupus erythematosus: what can neuromuscular ultrasonography (NMUS) tell us? A cross-sectional study. *Lupus Sci Med.* 2021;8(1):e000521. doi:10.1136/lupus-2021-000521
38. Cha YH, O J, Park J-K, Yang H-M, Kim SH. Ultrasound-guided versus blind temporomandibular joint injections: a pilot cadaveric evaluation. *Int J Oral Maxillofac Surg.* 2019;48(4):540–545. doi:10.1016/j.ijom.2018.09.002
39. Nielsen JV, Berg LC, Thoenert MB, Thomsen PD. Accuracy of ultrasound-guided intra-articular injection of cervical facet joints in horses: a cadaveric study. *Equine Vet J.* 2003;35(7):657–661. doi:10.2746/042516403775696366
40. Hanson P, Kivitz A, Mehra P, et al. Safety and systemic exposure of triamcinolone acetonide following ultrasound-guided intra-articular injection of triamcinolone extended-release or standard triamcinolone acetonide in patients with shoulder osteoarthritis: an open-label, randomized study. *Drugs R D.* 2021;21(3):285–293. doi:10.1007/s40268-021-00348-1
41. Sharma GK, Botchu R. Ultrasound guided injection of the rotator interval - Gaurav-Botchu technique. *J Ultrason.* 2021;21(84):77–79. doi:10.15557/JoU.2021.0013
42. Delle Sedie A, Riente L, Iagnocco A, et al. Ultrasound imaging for the rheumatologist XLVI. Ultrasound guided injection in the shoulder: a descriptive literature review. *Clin Exp Rheumatol.* 2013;31(4):477–483.
43. Ricci V, Özçakar L. Ultrasound-Guided Intra-articular Injection of the Elbow: targeting Deep to Anconeus Muscle. *Pain Med.* 2020;21(11):3242–3243. doi:10.1093/pm/pnaa063
44. Wang Y, Wang S, Luan S, et al. Accuracy and Feasibility of Ultrasound-Guided Intra-articular Injection of the Rat Hip Joint. *Ultrasound Med Biol.* 2021;47(10):2936–2940. doi:10.1016/j.ultrasmedbio.2021.06.003
45. Pai RS, Vas L. Ultrasound-Guided Intra-articular Injection of the Radio-ulnar and Radio-humeral Joints and Ultrasound-Guided Dry Needling of the Affected Limb Muscles to Relieve Fixed Pronation Deformity and Myofascial Issues around the Shoulder, in a Case of Complex Regional Pain Syndrome Type I. *Pain Pract.* 2018;18(2):273–282. doi:10.1111/papr.12596
46. Koh SH, Lee SC, Lee WY, Kim J, Park Y. Ultrasound-guided intra-articular injection of hyaluronic acid and ketorolac for osteoarthritis of the carpometacarpal joint of the thumb: a retrospective comparative study. *Medicine.* 2019;98(19):e15506. doi:10.1097/MD.00000000000015506
47. Bardowski EA, Byrd JWT. Ultrasound-Guided Intra-Articular Injection of the Hip: the Nashville Sound. *Arthrosc Tech.* 2019;8(4):e383–e8. doi:10.1016/j.eats.2018.11.016
48. Migliore A, Tormenta S, Martin LS, et al. Open pilot study of ultrasound-guided intra-articular injection of hylan G-F 20 (Synvisc) in the treatment of symptomatic hip osteoarthritis. *Clin Rheumatol.* 2005;24(3):285–289. doi:10.1007/s10067-004-1009-1
49. Fusco G, Gambaro FM, Di Matteo B, Kon E. Injections in the osteoarthritic knee: a review of current treatment options. *EFORT Open Rev.* 2021;6(6):501–509. doi:10.1302/2058-5241.6.210026
50. Lueders DR, Smith J, Sellon JL. Ultrasound-Guided Knee Procedures. *Phys Med Rehabil Clin N Am.* 2016;27(3):631–648. doi:10.1016/j.pmr.2016.04.010
51. Puebla DL, Farrow RA. 2021. *Ultrasound Guided Arthrocentesis*. Treasure Island (FL): StatPearls Publishing, StatPearls [Internet].
52. Sheth T, Miranda OM, Johnson B. Assessment of patient satisfaction, functionality, and quality of life after ultrasound-guided knee intervention: a prospective study. *Clin Rheumatol.* 2021;40(2):735–740. doi:10.1007/s10067-020-05254-6
53. Henning PT. Ultrasound-Guided Foot and Ankle Procedures. *Phys Med Rehabil Clin N Am.* 2016;27(3):649–671. doi:10.1016/j.pmr.2016.04.005
54. Paget LDA, Reurink G, de Vos RJ, et al. Effect of Platelet-Rich Plasma Injections vs Placebo on Ankle Symptoms and Function in Patients With Ankle Osteoarthritis: a Randomized Clinical Trial. *JAMA.* 2021;326(16):1595–1605. doi:10.1001/jama.2021.16602
55. Jha AJ, Viner GC, McKissack H, et al. Accuracy of talonavicular injection using ultrasound versus anatomical landmark: a cadaver study. *Acta Radiol.* 2020;61(10):1359–1364. doi:10.1177/0284185120901507
56. Henning T, Finnoff JT, Smith J. Sonographically guided posterior subtalar joint injections: anatomic study and validation of 3 approaches. *PM R.* 2009;1(10):925–931. doi:10.1016/j.pmrj.2009.09.006
57. Emami Razavi SZ, Azadvari M, Fateh HR, et al. Short-term Efficacy of Ultrasonographic Guidance for Intra-articular Corticosteroid Injection in Hallux Rigidus: a Single-Blind Randomized Controlled Trial. *Foot Ankle Int.* 2021;42(11):1410–1418. doi:10.1177/10711007211015988
58. Hao M, Baig S, Jo SY. Ultrasound guided aspiration of massive periarticular calcinosis in patient with scleroderma. *Clin Imaging.* 2021;78:110–112. doi:10.1016/j.clinimag.2021.03.019
59. Malanga GA, Chirichella PS, Hogaboom NS, Capella T. Clinical evaluation of micro-fragmented adipose tissue as a treatment option for patients with meniscus tears with osteoarthritis: a prospective pilot study. *Int Orthop.* 2021;45(2):473–480. doi:10.1007/s00264-020-04835-z
60. Burnham R, Smith A, Hart D. The safety and effectiveness of bone marrow concentrate injection for knee and hip osteoarthritis: a Canadian cohort. *Regen Med.* 2021;16(7):619–628. doi:10.2217/rme-2021-0001
61. Junaid SE, Bilal S, Saifuddin A. Suspected intra-articular soft-tissue tumours and tumour-like lesions: performance of image-guided core needle biopsy. *Eur J Radiol.* 2021;135:109469. doi:10.1016/j.ejrad.2020.109469
62. Huang Y, Deng Q, Yang L, et al. Efficacy and Safety of Ultrasound-Guided Radiofrequency Treatment for Chronic Pain in Patients with Knee Osteoarthritis: a Systematic Review and Meta-Analysis. *Pain Res Manag.* 2020;2020:2537075. doi:10.1155/2020/2537075
63. Wong PK, Kokabi N, Guo Y, et al. Safety and efficacy comparison of three- vs four-needle technique in the management of moderate to severe osteoarthritis of the knee using cooled radiofrequency ablation. *Skeletal Radiol.* 2021;50(4):739–750. doi:10.1007/s00256-020-03619-1
64. Hsieh LF, Hsu WC, Lin YJ, Wu SH, Chang KC, Chang HL. Is ultrasound-guided injection more effective in chronic subacromial bursitis? *Med Sci Sports Exerc.* 2013;45(12):2205–2213. doi:10.1249/MSS.0b013e31829b183c

65. Wu Y, Chen Q, Chen K, et al. Clinical efficacy of ultrasound-guided injection in the treatment of olecranon subcutaneous bursitis. *J Xray Sci Technol.* 2019;27(6):1145–1153. doi:10.3233/XST-190562
66. Park GY, Kwon DR, Cho HK, Park J, Park JH. Distribution of Platelet-rich Plasma after Ultrasound-Guided Injection for Chronic Elbow Tendinopathies. *J Sports Sci Med.* 2017;16(1):1–5.
67. Malahias MA, Nikolaou VS, Johnson EO, Kaseta MK, Kazas ST, Babis GC. Platelet-rich plasma ultrasound-guided injection in the treatment of carpal tunnel syndrome: a placebo-controlled clinical study. *J Tissue Eng Regen Med.* 2018;12(3):e1480–e8. doi:10.1002/term.2566
68. Callegari L, Spanò E, Bini A, Valli F, Genovese E, Fugazzola C. Ultrasound-guided injection of a corticosteroid and hyaluronic acid: a potential new approach to the treatment of trigger finger. *Drugs R D.* 2011;11(2):137–145. doi:10.2165/11591220-000000000-00000
69. Cecen GS, Gulabi D, Saglam F, Tanju NU, Bekler HI. Corticosteroid injection for trigger finger: blinded or ultrasound-guided injection? *Arch Orthop Trauma Surg.* 2015;135(1):125–131. doi:10.1007/s00402-014-2110-9
70. Latini E, Curci ER, Nusca SM, et al. Medical ozone therapy in facet joint syndrome: an overview of sonoanatomy, ultrasound-guided injection techniques and potential mechanism of action. *Med Gas Res.* 2021;11(4):145–151. doi:10.4103/2045-9912.318859
71. Sconfienza LM, Perrone N, Lacelli F, Lentino C, Serafini G. Ultrasound-guided injection of botulinum toxin A in the treatment of iliopsoas spasticity. *J Ultrasound.* 2008;11(3):113–117. doi:10.1016/j.jus.2008.05.002
72. Heaver C, Pinches M, Kuiper JH, et al. Greater trochanteric pain syndrome: focused shockwave therapy versus an ultrasound guided injection: a randomised control trial. *Hip Int;*2021. 112070002110603. doi:10.1177/11207000211060396
73. Tagliafico AS, Torri L, Signori A. Treatment of meralgia paresthetica (Lateral Femoral Cutaneous Neuropathy): a meta-analysis of ultrasound-guided injection versus surgery. *Eur J Radiol.* 2021;139:109736. doi:10.1016/j.ejrad.2021.109736
74. Lee JH, Lee JU, Yoo SW. Accuracy and efficacy of ultrasound-guided pes anserinus bursa injection. *J Clin Ultrasound.* 2019;47(2):77–82. doi:10.1002/jcu.22661
75. Abate M, Di Carlo L, Verna S, Di Gregorio P, Schiavone C, Salini V. Synergistic activity of platelet rich plasma and high volume image guided injection for patellar tendinopathy. *Knee Surg Sports Traumatol Arthrosc.* 2018;26(12):3645–3651. doi:10.1007/s00167-018-4930-6
76. Mlosek RK, Skrzypek E, Migda B, Migda M, Woźniak W. The efficacy of high-frequency ultrasound-guided injection lipolysis in reducing fat deposits located on the inside of the knees. *J Ultrason.* 2021;20(83):e273–e8. doi:10.15557/JoU.2020.0048
77. Sofka CM, Adler RS. Ultrasound-guided interventions in the foot and ankle. *Semin Musculoskelet Radiol.* 2002;6(2):163–168. doi:10.1055/s-2002-32362
78. Ahadi T, Nik SS, Forogh B, Madani SP, Raissi GR. Comparison of the Effect of Ultrasound-Guided Injection of Botulinum Toxin Type-A and Corticosteroid in the Treatment of Chronic Plantar Fasciitis: a Randomized Controlled Trial. *Am J Phys Med Rehabil.* 2021. doi:10.1097/PHM.0000000000001900
79. Ruiz Santiago F, Prados Olleta N, Tomás Muñoz P, Guzmán Álvarez L, Martínez Martínez A. Short term comparison between blind and ultrasound guided injection in morton neuroma. *Eur Radiol.* 2019;29(2):620–627. doi:10.1007/s00330-018-5670-1
80. Frederiksen CA, Juhl-Olsen P, Sloth E. Advances in imaging: ultrasound in every physician's pocket. *Expert Opin Med Diagn.* 2012;6(3):167–170. doi:10.1517/17530059.2012.669368
81. Soneji N, Peng PW. Ultrasound-Guided Interventional Procedures in Pain Medicine: a Review of Anatomy, Sonoanatomy, and Procedures: part VI: ankle Joint. *Reg Anesth Pain Med.* 2016;41(1):99–116. doi:10.1097/AAP.0000000000000344
82. Sadeghi N, Kumar A, Kim J, Dooley J. Images in Anesthesiology: ultrasound-guided Intraarticular Knee Injection. *Anesthesiology.* 2017;127(3):565. doi:10.1097/ALN.0000000000001616
83. Kampen WU, Boddenberg-Pätzold B, Fischer M, et al. The EANM guideline for radiosynoviorthesis. *Eur J Nucl Med Mol Imaging.* 2021;49(2):681–708. doi:10.1007/s00259-021-05541-7
84. Sattui SE, Liew JW, Kennedy K, Sirotych E, Putman M, Moni TT. Early experience of COVID-19 vaccination in adults with systemic rheumatic diseases: results from the COVID-19 Global Rheumatology Alliance Vaccine Survey. *RMD Open.* 2021;7(3):e001814. doi:10.1136/rmdopen-2021-001814
85. Bliddal H, Terslev L, Qvistgaard E, et al. Safety of intra-articular injection of etanercept in small-joint arthritis: an uncontrolled, pilot-study with independent imaging assessment. *Joint Bone Spine.* 2006;73(6):714–717. doi:10.1016/j.jbspin.2006.05.004
86. Falkowski AL, Jacobson JA, Freehill MT, Kalia V. Hand-Held Portable Versus Conventional Cart-Based Ultrasound in Musculoskeletal Imaging. *Orthop J Sports Med.* 2020;8(2):2325967119901017. doi:10.1177/2325967119901017
87. Cohen SP, Baber ZB, Buvanendran A, et al. Pain Management Best Practices from Multispecialty Organizations During the COVID-19 Pandemic and Public Health Crises. *Pain Med.* 2020;21(7):1331–1346. doi:10.1093/pm/pnaa127
88. Abualfadl E, Ismail F, Shereef RRE, Hassan E, Tharwat S; ECR COVID19-Study Group. Impact of COVID-19 pandemic on rheumatoid arthritis from a Multi-Centre patient-reported questionnaire survey: influence of gender, rural-urban gap and north-south gradient. *Rheumatol Int.* 2021;41(2):345–353. doi:10.1007/s00296-020-04736-9
89. Mitchell WG, Kettwich SC, Sibbitt WL, et al. Outcomes and cost-effectiveness of ultrasound-guided injection of the trochanteric bursa. *Rheumatol Int.* 2018;38(3):393–401. doi:10.1007/s00296-018-3938-z
90. Richez C, Flipo RM, Berenbaum F, et al. Managing patients with rheumatic diseases during the COVID-19 pandemic: the French Society of Rheumatology answers to most frequently asked questions up to May 2020. *Joint Bone Spine.* 2020;87(5):431–437. doi:10.1016/j.jbspin.2020.05.006
91. Hammam N, Tharwat S, Shereef RRE, Elsaman AM, Khalil NM. Egyptian College of Rheumatology (ECR) COVID-19 Study Group. Rheumatology University faculty opinion on coronavirus disease-19 (COVID-19) vaccines: the vaXurvey study from Egypt. *Rheumatol Int.* 2021;41(9):1607–1616. doi:10.1007/s00296-021-04941-0
92. Bernuzzi G, Petraglia F, Pedrini MF, et al. Use of platelet-rich plasma in the care of sports injuries: our experience with ultrasound-guided injection. *Blood Transfus.* 2014;12 Suppl 1(Suppl 1):s229–34. doi:10.2450/2013.0293-12
93. Reveille J. EULAR recommendations reflect advances in imaging. *Nat Rev Rheumatol.* 2015;11:388–389. doi:10.1038/nrrheum.2015.80
94. Umphrey GL, Brault JS, Hurdle MF, Smith J. Ultrasound-guided intra-articular injection of the trapeziometacarpal joint: description of technique. *Arch Phys Med Rehabil.* 2008;89(1):153–156. doi:10.1016/j.apmr.2007.07.048
95. Scoppettuolo G, Biasucci DG, Pittiruti M. Vascular access in COVID-19 patients: smart decisions for maximal safety. *J Vasc Access.* 2020;21(4):408–410. doi:10.1177/1129729820923935

96. Aletaha D, Neogi T, Silman AJ, et al. 2010 Rheumatoid arthritis classification criteria: an American College of Rheumatology/European League Against Rheumatism collaborative initiative. *Arthritis Rheum.* 2010;62(9):2569–2581. doi:10.1002/art.27584
97. Aguilera L, Pérez-Giner R, Higuera-Guerrero V, Belloch-Ramos E, Cuenca-Torres M, Juan EL. Can collagenase effectiveness in Dupuytren's contracture be improved by using ultrasound-guided Injection? A comparative study. *J Plast Surg Hand Surg.* 2021;2:1–7.
98. Mandl P, Navarro-Compán V, Terslev L, Aegerter P. FRI0127 Euler Recommendations for the Use of Imaging in Spondyloarthritis in Clinical Practice. *Ann Rheum Dis.* 2014;73:427–428.
99. Gheita TA, Eesa NN. Rheumatology in Egypt: back to the future. *Rheumatol Int.* 2019;39(1):1–12. doi:10.1007/s00296-018-4192-0
100. Jacobson JA, Kim SM, Brigido MK. Ultrasound-Guided Percutaneous Tenotomy. *SeminMusculoskeletRadiol.* 2016;20(5):414–421.
101. Parisi S, Ditto MC, Priora M, et al. Ultrasound-guided intra-articular injection: efficacy of hyaluronic acid compared to glucocorticoid in the treatment of knee osteoarthritis. *Minerva Med.* 2019;110(6):515–523. doi:10.23736/S0026-4806.19.06190-1

Open Access Rheumatology: Research and Reviews

Dovepress

Publish your work in this journal

Open Access Rheumatology Research and Reviews is an international, peer-reviewed, open access journal publishing original research, reports, editorials, reviews and commentaries on all aspects of clinical and experimental rheumatology in the clinic and laboratory including the following topics: Pathology, pathophysiology of rheumatological diseases; Investigation, treatment and management of rheumatological diseases; Clinical trials and novel pharmacological approaches for the treatment of rheumatological disorders. The manuscript management system is completely online and includes a very quick and fair peer-review system, which is all easy to use. Visit <http://www.dovepress.com/testimonials.php> to read real quotes from published authors.

Submit your manuscript here: <https://www.dovepress.com/open-access-rheumatology-research-and-reviews-journal>