Ultrasound / Interview report

Applications of diagnostic ultrasound systems in the field of orthopaedics

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Introduction

The applications of diagnostic ultrasound systems in the field of orthopaedics have expanded greatly, from simply performing diagnostic scans to conducting advanced therapeutic procedures and monitoring rehabilitation training. We interviewed Dr. Makoto Wada, Director of Wada Orthopaedic Clinic, and asked him to discuss the clinical value of musculoskeletal (MSK) ultrasound at his facility, where ultrasound is actively employed as a part of their routine clinical practice.

Role of ultrasound in the field of orthopaedics

Dr. Wada founded Wada Orthopaedic Clinic in Hirakata city, Osaka, Japan, in 2004. The clinic provides a wide range of advanced medical care, including sports MSK as well as general MSK services. When Dr. Wada started using ultrasound, he found it particularly useful for performing injection under ultrasound guidance. He says, "Initially, I started using ultrasound out of a vague sense of necessity. The ultrasound system we purchased 15 years ago didn't provide any additional diagnostic information other than demonstrating the presence of hematoma in muscle strains. However, due to technological advances, it later became possible to observe smaller injuries and structural changes, providing a much greater sense of realism. This made us feel that we would soon be entering a new era with a wider range of therapeutic options. Back when it was standard practice to perform joint injection without ultrasound guidance, I frequently encountered cases in which the solution wasn't properly injected into the articular cavity. A number of studies published before the routine use of ultrasound also reported many cases in which the solution couldn't be properly injected into the subacromial bursa. Of course, one of the main advantages of ultrasound is that it allows the solution to be precisely delivered to the target site. But another important advantage is that the pathology can be observed while performing treatment (Fig. 1). If the treatment isn't as effective as expected even though the solution is correctly injected into the target site, we should consider the possibility of a different pathological process. Also, I think ultrasound has proven useful for clarifying the pathology in cases of frozen shoulder, a condition which was previously not well understood. In my practice, I've always found it interesting that the pathological changes observed in frozen shoulder vary from patient to patient, suggesting that the cause of frozen shoulder also varies. I think it's truly fascinating to evaluate the locomotor system of the entire body using ultrasound."

Challenges in the diagnosis and treatment of muscle strains using ultrasound and MRI

Wada Orthopaedic Clinic offers a range of clinical services related to the diagnosis and treatment of muscle strains. In general, MRI is the modality of choice for the diagnosis of muscle strains, but Dr. Wada also uses ultrasound. "In the past, I used palpation to evaluate tenderness and to check for the presence of damage to soft tissues such as the muscles, ligaments, and tendons. However, when a lesion was located in deep tissues, it was often difficult to localize the point of tenderness. I'd order an MRI examination when detailed structural evaluation of the pathology was required. But today, thanks to the high spatial resolution of modern diagnostic ultrasound systems, we often use ultrasound for the detailed evaluation of such lesions. One of the weaknesses of MRI is that it isn't the ideal modality for obtaining oblique image slices. For example, it's very important to evaluate the proximal part of the common tendon of the hamstrings, which is a common site of injury. But because the tendons and muscle fibers run obliquely at the muscle-tendon junctions, it can be difficult to obtain images with sufficient detail using MRI. Ultrasound is extremely useful for examining these structures because the transducer can be freely moved to acquire images from any desired direction."

In addition, Dr. Wada places special emphasis on the clinical value of using ultrasound in combination with MRI. "When formulating treatment plans focusing on return-to-play, it's essential to precisely localize the area of injured muscle tissue, to analyze the specific movements related to the affected muscle, and to identify the movements that could lead to recurrence of symptoms. These can all be precisely evaluated using ultrasound. I believe that, in the future, it will become standard practice to perform ultrasound examination in addition to MRI."

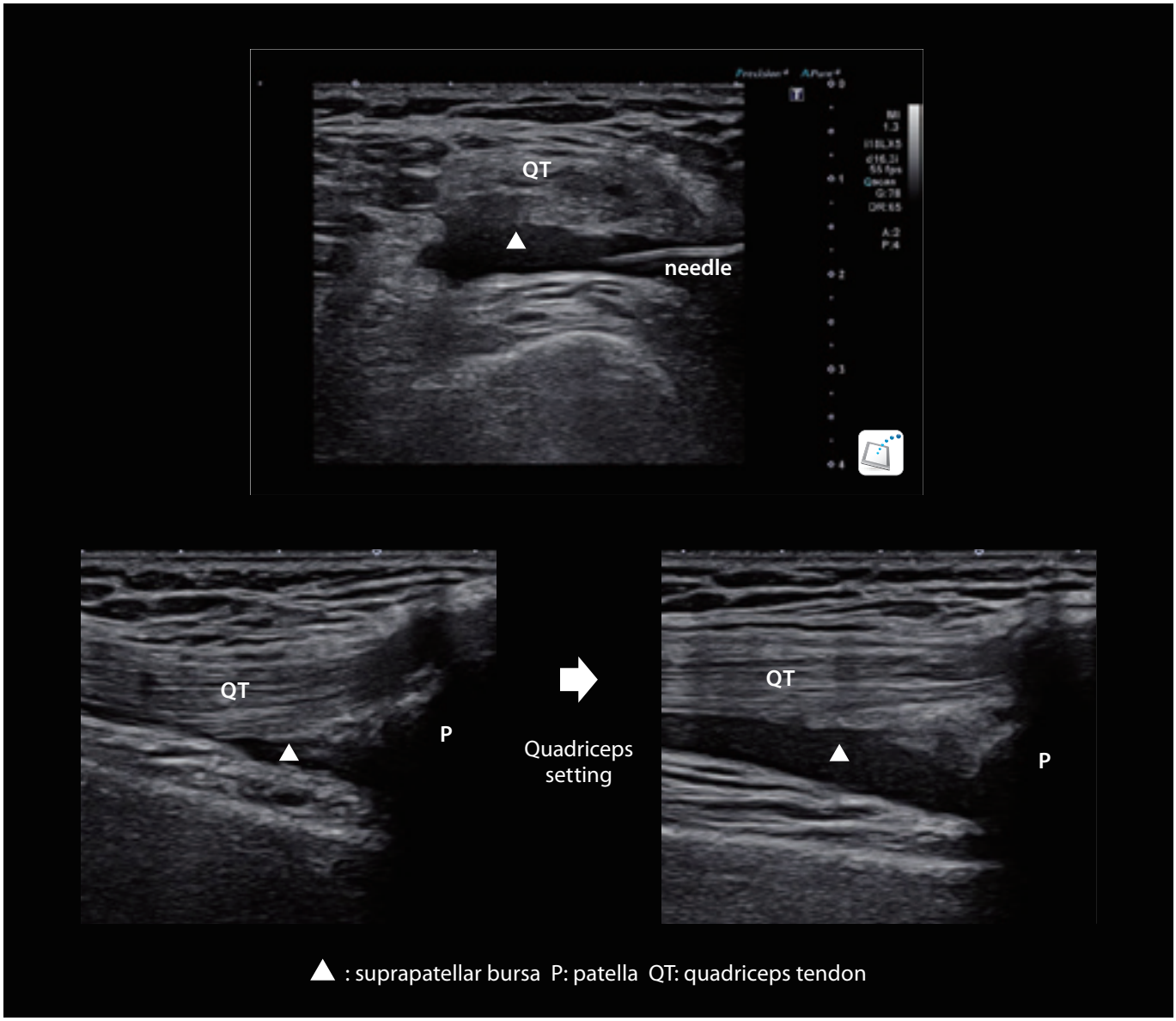

Figure 1 Ultrasound-guided knee joint injection with quadriceps setting
(Makoto W. et al: JBJS. 2018; 3(4): e0003)

Clinical benefits of high-end diagnostic ultrasound systems in orthopaedics

Ultrasound offers many important benefits in clinical practice. Dr. Wada explains, "Ultrasound allows us to perform examinations while showing the images to the patient, which helps them follow our explanations and clearly understand their clinical condition. In particular, top-level athletes often want to rush back into training for the earliest possible return-to-play. The ability to discuss their condition while showing them actual images of the affected region is very helpful for giving them a clearer idea of when they can safely resume training." Dr. Wada also notes that ultrasound has led to improved communication with their physical therapists. "At our clinic, physicians perform 5-minute examinations and physical therapists perform 20-minute examinations for each patient to carefully evaluate the pathology using ultrasound. This helps to ensure that our patients receive the best possible care. For example, if a patient's pain is relieved by performing hydro-dissection while observing the area using ultrasound, we can get a clearer understanding of the location of the pathology (Fig. 2). We then discuss the findings with the physical therapists so they can provide optimal care to prevent adhesion or anchoring. The use of ultrasound images has made it much easier to review the pathological findings with our physical therapists."

Wada Orthopaedic Clinic provides advanced medical services using their high-end ultrasound system model Aplio i700 / Prism Edition, manufactured by Canon. With regard to their system, Dr. Wada states, "The image quality is great. Thanks to its high-end capabilities, deep regions can be clearly visualized. And Full Focus allows an overall view to be displayed in good focus, eliminating the time and effort of setting the focus every time."

Dr. Wada explains that he mainly uses the PLI-1205BX and PLI-605BX transducers in routine practice. "I generally use PLI-1205BX to perform routine examinations, but I also use PLI-605BX to evaluate muscle strains in deep regions such as the hamstrings, to examine the sciatic nerve in cases of piriformis syndrome, and to precisely insert needles in deep regions (Fig. 3). For examinations in which ultrasound attenuation is likely to occur, such as examinations to evaluate plantar aponeurositis, I also use PLI-605BX even when the lesion is located in superficial tissues." Dr. Wada says he has also recently begun to examine the nerves of the pelvis using ultrasound. "When examining the nerves of the pelvis, I first use a convex transducer. Convex transducers are good for obtaining an overall view of the deep tissues, but they can't provide detailed images of the nerves and other fine structures. The positions of the spine, the colon in the abdomen, and the uterus in the pelvis can be observed using a convex transducer. When I'm checking for herniation of an intervertebral disc or examining a nerve root passing through an intervertebral foramen, I first make sure that the intestines don't interfere by pushing them aside with the convex transducer. I then switch to the PLI-605BX transducer (Fig. 4). If it's difficult to see the target region from a dorsal approach, it's often possible to obtain a clear view by switching to a ventral approach."

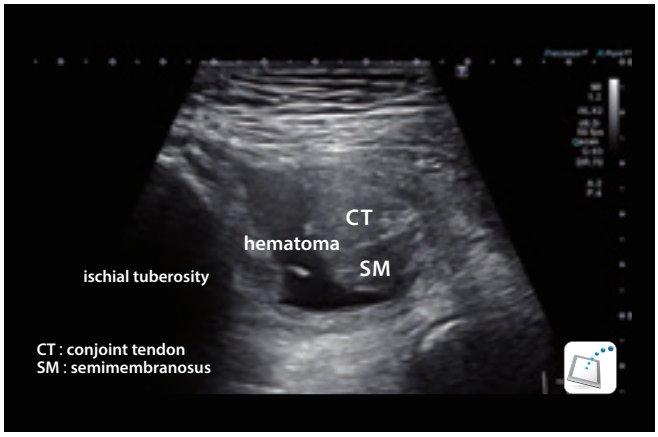

Figure 3 A case of rupture of the hamstring origin tendon (PLI-605BX)

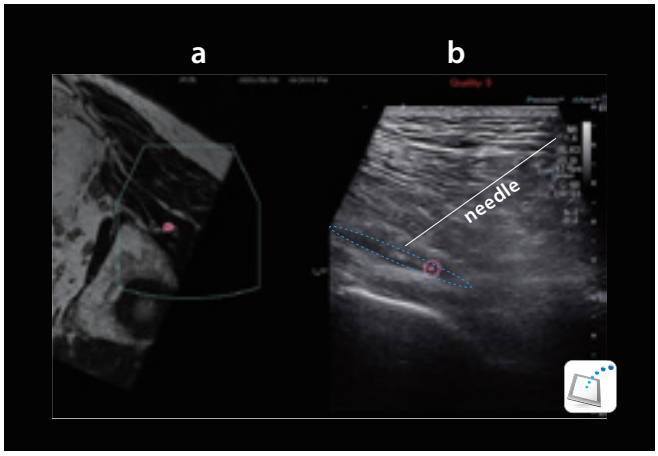

Figure 2 A case of Beaton Type B piriformis syndrome in which a portion of the sciatic nerve (peroneal nerve component) runs within the piriformis muscle
a: MRI image b: B-mode image

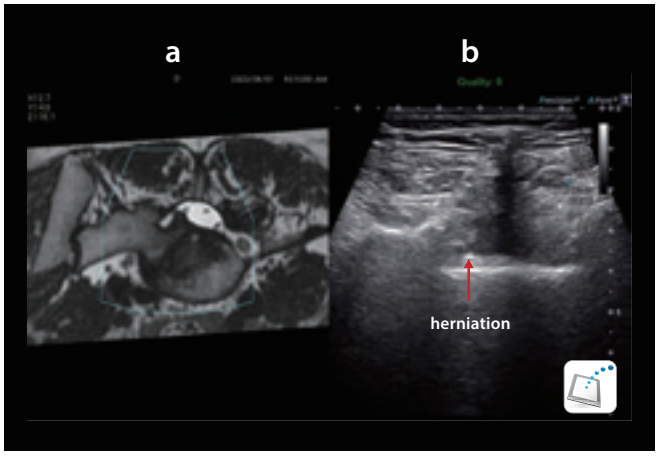

Figure 4 Case of disc herniation on the right side of L5/S1 (PLI-605BX)
a: MRI image b: B-mode image

Changes in clinical practice with SMI and Smart Fusion

Among the various advanced applications included in Aplio i-series / Prism Edition, Dr. Wada observes that Superb Micro-vascular Imaging (SMI), which is a technology for visualizing low-velocity blood flow, is the function that has led to the greatest changes in clinical practice. "SMI suppresses noise even when the Doppler scale is lowered, so it's very useful for evaluating low-velocity blood flow. Fine nerves are difficult to visualize, so when performing hydro-dissection, their locations can be determined by identifying the arteries that run parallel to them. In many patients with intractable tendon disorders, SMI is useful for evaluating pathological changes as well as for performing procedures such as curettage of neovascularization affecting a tendon and injection of steroids into the surrounding inflamed bursa. Because such blood flow images rarely suffer from blurring, it's possible to obtain accurate information for guiding the needle tip precisely to the target. In addition, in patients with muscle strains, observing the changes in soft tissues over time using SMI allows us not only to monitor the healing process but also to check for progression or recurrence of the injury (Fig. 5)."

Dr. Wada also appreciates the clinical usefulness of Smart Fusion, which is an application for displaying previously acquired CT and MRI images for reference while also viewing real-time ultrasound images during scanning. He often uses Smart Fusion to display reference MRI images together with the ultrasound images (Fig. 6, Fig. 7). "The ability to display MRI and ultrasound images together is of great clinical value because each imaging modality can compensate for the limitations of the other. One of the weak points of ultrasound is that it's difficult to obtain qualitative information.

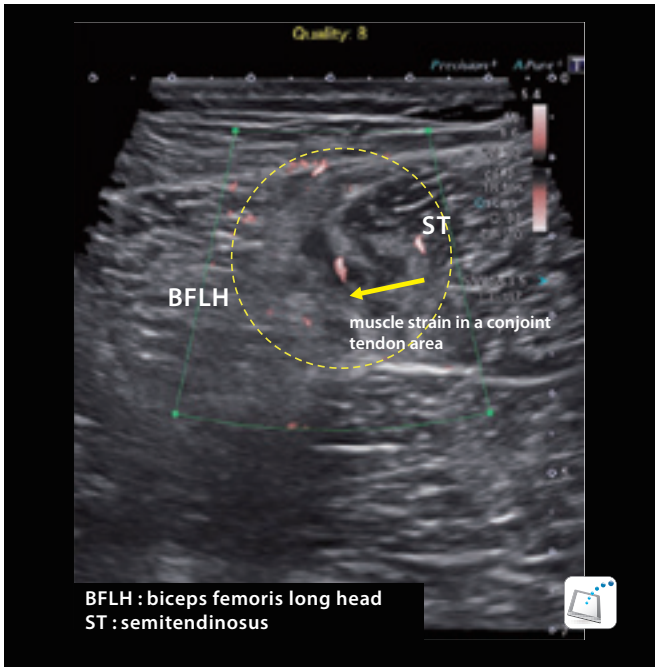

Figure 5 Observation of the healing status from a muscle strain in a conjoint tendon area with SMI

For example, although the continuity of a tendon can be confirmed, the strength of the tendon can't be determined. In such cases, the continuity can be evaluated based on the findings seen in ultrasound images while the strength can be estimated based on the changes in intensity observed in MRI images. The MRI findings provide important information for understanding the changes in thickness and for precisely evaluating the changes during the remodeling process. The weak point of MRI is that it's not very good for visualizing structural details. But when we use Smart Fusion, simply moving the transducer allows us to view the MRI findings in three dimensions. Follow-up observation of the injured area is also important. In examinations using ultrasound alone, because morphological changes occur as swelling subsides during the healing process, it can be difficult to identify the exact location corresponding to a previously placed marker. But if the same region is viewed in an MRI image displayed beside the ultrasound image, it's much easier to appreciate the morphological changes over time while examining the injured area. Also, when SMI is used in combination, the areas of remodeling during the healing process can be accurately identified, resulting in higher reproducibility."

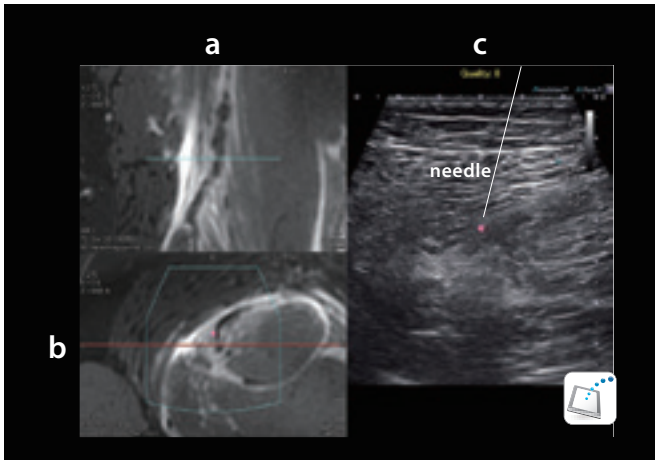

Figure 6 Fusion-guided PRP injection in the multi-mode for a hamstring strain in the proximal conjoint tendon
a: Cross-section of the red line on the MRI in c b: MRI image in the same view as the ultrasound image c: B-mode image

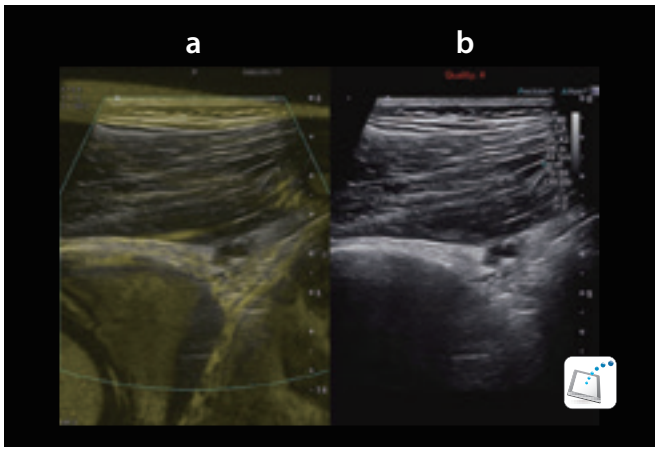

Figure 7 Evaluation of the piriformis muscle area
a: Blend mode superimposing MRI and ultrasound images b: B-mode

The future of MSK ultrasound

As the interview concludes, Dr. Wada focuses on the future role of ultrasound in the field of orthopaedics, particularly for the treatment of muscle strains. "Most sports injuries involve damage to soft tissues. MRI is the most commonly used modality worldwide for the evaluation and classification of such injuries. Taking muscle strains as an example, injuries are evaluated using the following classification: tendon tears, muscle-tendon junction tears, intramuscular tendon injuries, myofascial injuries, and intramuscular myofiber tears. But if an injury involves a common tendon shared by two muscles, the amount of stress is increased. In addition, the amount of stress applied differs depending on the structural characteristics of the myofibers, such as whether a muscle is bipennate or fusiform. In the future, as ultrasound technology continues to advance, it will become possible to perform even more detailed evaluation. It's my hope that the use of ultrasound and MRI in combination will allow us to determine the optimal timing for return-to-play, taking into account the muscle which has been injured and the precise location of the injury. I'm really looking forward to such a future!"

"The image quality of the Aplio i-series / Prism Edition is great. Thanks to its high-end capabilities, deep regions can be clearly visualized."

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