The Role of Handheld Point-of-Care Musculoskeletal Ultrasound in Identifying Bone Injury: A Multi-Case Report

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ABSTRACT

Introduction: Ultrasound is not a commonly recommended imaging modality for evaluating bone. The purpose of this report is to illustrate the usefulness of handheld ultrasound in identifying bone injury through the use of three case examples. As handheld ultrasound units are the least expensive imaging equipment, they may be the only option available or may readily complement radiographs.

Cases:
1) 37-year-old male, hit from behind by a trailer while on his bike. Right shoulder dislocation relocated at the hospital. Radiographs confirmed relocation. A Hill-Sachs deformity was identified via handheld ultrasound.
2) 67-year-old woman, reported with a hyperinversion ankle injury, 3 weeks post injury. Initial radiographs concluded there was no fracture. An avulsion was identified via handheld ultrasound.
3) 69-year-old woman presented for a lymphatic massage. The massage therapist called for an urgent consult as her pain with moving was unusual. Pain located at right lateral ribs 7-9. Pain began following a thoracic manipulation a week prior. A rib fracture was identified via handheld ultrasound.

Conclusion: Handheld point-of-care ultrasound can be used to identify a bone injury and can complement radiographs.

Key Words: Hill-Sachs, fracture, avulsion, point-of-care ultrasound, POCUS

INTRODUCTION

When suspecting a bone injury, radiographs are often the first imaging modality that comes to mind due to their low cost and availability compared to computed tomography (CT) or magnetic resonance imaging (MRI). For example, the American Board of Surgeon's imaging guidelines recommend radiographs, then CT/MRI as needed.[1] Musculoskeletal (MSK) ultrasound's use is fairly young, with the Alliance for Physician Certification & Advancement (APCA) and the American Registry for Diagnostic Medical Sonography (ARDMS) only creating a specialty certification (RMSK/RMSKS) in 2012.[2] MSK ultrasound also requires a high frequency linear probe ≥ 12Hz with ideally 196 elements or more.[3] Handheld ultrasound units have improved greatly in recent years with multiple models that meet this criteria such as the Clarius L7/15/22 HD3 and GE Vscan Air CL.[4,5] These units can be purchased for approximately $4,200-$4,900 USD, at the time of this writing, which makes them an affordable imaging modality that requires no special installation, dedicated space, or special considerations due to ionizing radiation.[6,7]

Ultrasound is known for its ability to image soft tissues. In that context, bones are often used as landmarks or are seen as an inconvenience, as the cortex is such a strong reflector that structures behind a bone cannot be imaged. Being such a strong reflector, ultrasound produces a clear outline of the cortex, and can evaluate its form, but is limited to a very narrow window. You are limited by the size of the transducer head and to areas to which you can image. For example, you cannot evaluate the ribs under the scapula or the superior rim of the glenoid due to the scapula and the acromion, respectively, blocking direct access. The European Federation of Societies for Ultrasound in Medicine and Biology (EFSUMB) made a series of evidence-based recommendations for MSK ultrasound use in 2022.[8] These are their recommendations as they apply to bone:[8]

1. Ultrasound (US) should be used to detect peripheral enthesophytes and erosions (Level-of-Evidence(LoE) 1, Strength-of-Recommendation(SoR) strong). Broad consensus (88%).

2. In accessible bone areas, when radiography is negative but clinical suspicion of acute fracture is high, US should be used (LoE 1, SoR strong). Strong consensus (95%).

3. In regions with an acoustic window, US should be used for monitoring fracture healing (LoE 2, SoR strong). Broad consensus (76%).

4. In regions with an acoustic window, US might be used to detect periostitis (LoE 4, SoR weak). Broad consensus (76%).

Note the recommendation with the strongest consensus is to use ultrasound for fractures when radiographs are negative. Ultrasound is reasonably good at identifying fractures: a 2019 meta-analysis examining the use of ultrasound to identify fractures determined a pooled sensitivity and specificity of 0.93 and 0.92 for upper limb fractures and 0.83 and 0.93 for lower limb fractures.[9]

To illustrate the ability of handheld ultrasound in a point-of-care setting for bone injury, three cases are presented: a Hill-Sachs defect, an avulsion, and a rib fracture. Each case features a brief discussion following the case presentation. Ultrasound imaging was performed with a handheld Clarius L15HD3 (Clarius Mobile Health Corp., Vancouver, BC, Canada) by a chiropractor.

CASE PRESENTATION AND DISCUSSION

Case 1: A 37-year-old male was struck by the edge of a trailer from behind while cycling. The right shoulder was dislocated anteriorly and was relocated at the hospital. Relocation was confirmed via radiographs (**Figure 1**). He reported to the clinic 10 days post-injury for treatment and was referred to a physiotherapist for co-management. A partial ultrasound was taken that day examining the most painful sites, but the scan was limited to the regions of pain due to time and the patient's limited range-of-motion (ROM). Myofascial trigger points were identified in the infraspinatus, and the biceps and subscapularis tendons appeared normal. On a check-up approximately 2.5 months later, with increased ROM the supraspinatus was evaluated via ultrasound (**Figure 2**). Decreased echogenicity of the supraspinatus tendon consistent with tendinosis was seen along with a cortical irregularity that, when combined with the patient's history, is consistent with a Hill-Sachs defect. This is not the first one identified via ultrasound though, with the earliest study completed in 1996.[10-12]

A 2021 systematic review of imaging modalities for Hill-Sachs lesions concluded that CT arthrography (CTA) is the most accurate with a median accuracy of 91%.[10] Accuracy is not the only factor and the authors discuss that MRI and ultrasound are both reasonable alternatives. MRI has a similar accuracy but has the added advantage of showing soft tissue injuries (like a capsular defect or bone marrow edema) and ultrasound may be only slightly less accurate (94% when compared with CTA and 91% compared to arthrography in one study).[10,11] Radiographs compared poorly with the other imaging modalities.[10] The authors comment on the gaining popularity of ultrasound: the relative lower cost, less time, and zero radiation exposure to the patient.[10,13] Despite its benefits, ultrasound has some important shortcomings to consider such as: the ROM of the patient might limit the evaluation, the interobserver reliability can be quite low ($\kappa = 0.4$ in one study), and only a fraction of the labrum can be evaluated.[11-13] Lack of exposure to using ultrasound to detect bone injuries might be a factor, even for those trained in MSK ultrasound. The chiropractor who performed the ultrasound study was taken aback by the humeral head's appearance because, despite multiple learning resources, he had never been exposed to the concept of identifying a Hill-Sachs lesion via ultrasound.[14-16] This suggests improvements in ultrasound educational resources may be in order, particularly for POCUS practitioners without access to other forms of imaging.

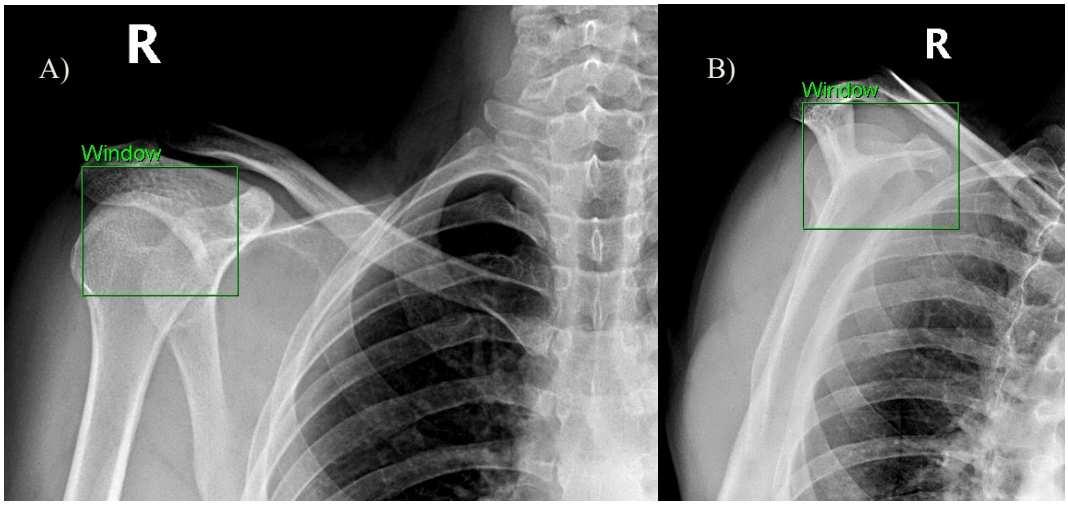

Figure 1: *Patient radiographs of the right shoulder post-relocation: (A) AP with internal rotation and (B) Scapular-Y view. Although not identified on the initial imaging report, a subtle cortical defect is suspected, particularly on the AP with internal rotation view.*

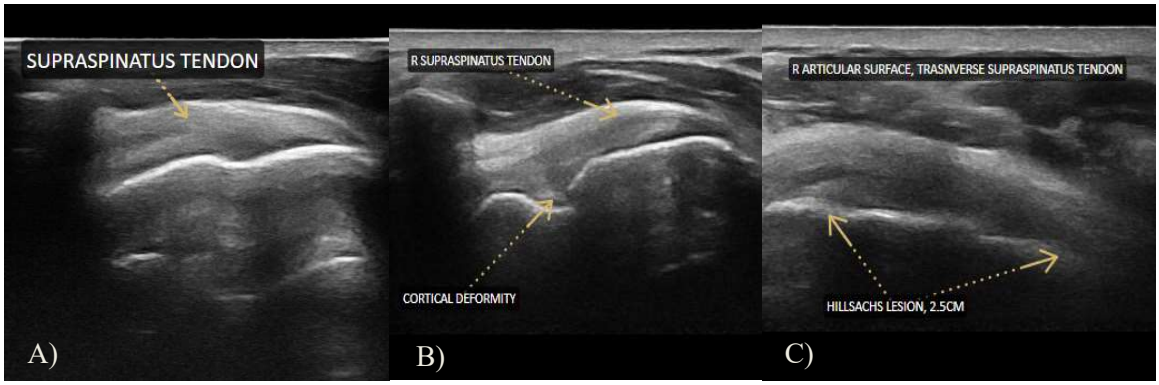

Figure 2: *A) Normal transverse view of the supraspinatus tendon. B) Transverse view of the patient's right supraspinatus tendon. Note the cortical deformity. C) Transverse view of the patient's supraspinatus tendon used to determine the extent of the cortical irregularity.*

Case 2: A 68-year-old female traveler. She had sprained her left ankle via hyperinversion by slipping on a rock in Spain. She was barred from her flight due to the extreme swelling noticed by the flight crew. A radiograph was taken at the hospital ruling out fracture. She reported to our clinic 3 weeks later for acupuncture and lymphatic massage. When she complained that the joint "didn't feel right" she was referred to the chiropractor for evaluation. Some edema was noted, and the anterior talo-fibular ligament (ATFL) region was tender to palpation. An ultrasound was performed showing the bright line of cortex where the ligament should be (**Figure 3**). This was diagnosed as an avulsion injury of the ATFL.

In a study by Takakura et al. comparing radiographs versus ultrasound, it was found that

ultrasound had an increased sensitivity (94% compared with 81%) for detecting avulsions of the ATFL. [17] A meta-analysis in 2019 concluded that ultrasound should be the first-line imaging modality of choice for ATFL evaluation.[18] Although MRI is also fairly accurate, ultrasound performs slightly better when compared with MRI with the added benefit of being more affordable.[19,20]

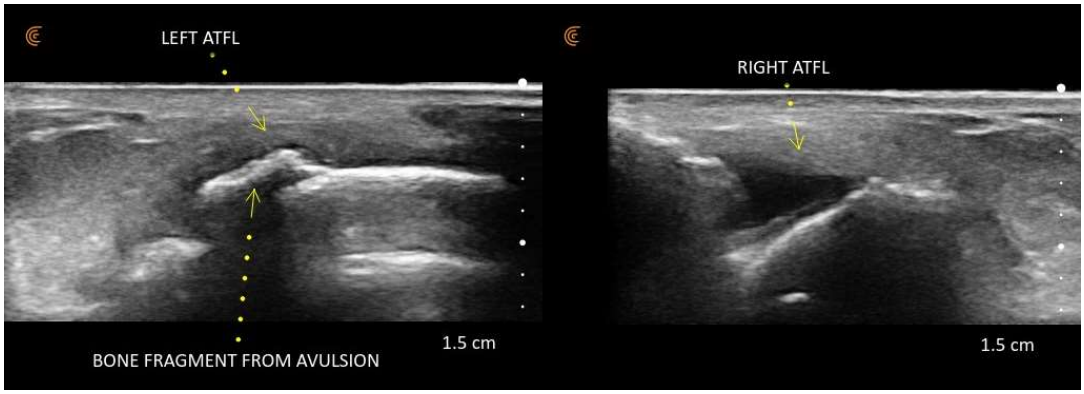

Figure 3: *Split screen view of the left ATFL and right ATFL. Notice the bright line of cortex spanning the majority of the left talo-fibular joint space. Note the lack of signal under the avulsion fragment (posterior acoustic shadowing artifact).*

Case 3: A 69-year-old woman came to the clinic for a massage. The massage therapist noticed her abnormally acute pain with movement and called the chiropractor in for an urgent consult. The pain was located in the right lower posterolateral rib region. Pain was aggravated with trunk movement and deep breathing. The region was tender to palpation. Vibration with a tuning fork against one of her tender ribs increased her pain. An ultrasound scan was performed (**Figure 4**) and there was a sharp discontinuity in the cortex indicating a fracture. She reported that the pain had started one week earlier when a chiropractor had "cracked" her back/ribs. Note that she was later diagnosed with Stage 4 breast cancer so the integrity of her ribs might have been compromised.

A recent retrospective study on the safety of chiropractic spinal manipulative therapy (SMT) found an incidence of severe adverse events was only 2 out of 960,140 SMT sessions.[21] Both recorded events were rib fractures in women >60 years of age with osteoporosis.[21] A rib fracture should be considered in any elderly woman who presents with sharp rib pain following a manipulation. As for diagnosing a rib fracture, ultrasound may be superior to radiographs.[22] In a 2017 study by Pishpin et al. it was found that ultrasound had detected 98% of rib fractures whereas oblique rib view and PA chest radiography detected 46% and 41% of rib fractures, respectively.[22] The authors further noted that ultrasound evaluations were also faster with ultrasounds taking 7-17 min while radiographs took 15-37 min as patients would have to travel to the radiology department and back whereas a portable ultrasound was used in the emergency room.[22]

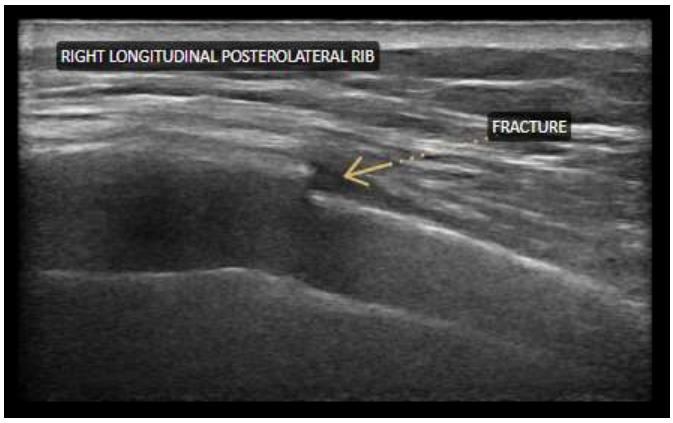

Figure 4: *Longitudinal view of a posterolateral rib. Note the discontinuity of the cortex indicating a fracture. The small hypoechoic region adjacent to the fracture site likely represents a hematoma.*

CONCLUSION

The usefulness of handheld ultrasound to diagnose bone injury was illustrated through three examples: a Hill-Sachs lesion, an avulsion, and a fracture. In two of the cases, radiographs had failed to diagnose the injury. While sonography is limited to regions with direct access, when it is viable, it may perform as well as MRI/CT and can have superior sensitivity to radiographs. Handheld ultrasound is a viable imaging modality for bone and a useful addition to radiographs.

CONSENT

Written consent for publication was obtained from the living patients.

COMPETING INTERESTS

The author offers ultrasound educational courses and consultations. The author declares no other competing interests.

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