SCIENTIFIC ARTICLE

The Validity and Reliability of a Pocket-Sized Ultrasound to Diagnose Distal Radius Fracture and Assess Quality of Closed Reduction

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Purpose Handheld ultrasound technology is increasingly used in health care. Its use for fracture care has not been adequately evaluated. The purpose of this study was to evaluate handheld, pocket-sized ultrasound in the diagnosis and assessment of reductions in distal radius fractures.

Methods A total of 23 patients with distal radius fractures (average age, 53 years; 13 women) and 20 control patients (average age, 53 years; 10 women) were prospectively enrolled. All patients with distal radius fractures underwent standard, 3-view radiographic and ultrasonographic examinations of the wrist before and after closed reduction. Control patients had a one-time standard radiographic and ultrasonographic examination of the wrist. Radiographs were used as the reference standard. All images were assessed for the presence or absence of a fracture by a board-certified, hand fellowship–trained orthopedic surgeon and musculoskeletal fellowship–trained radiologist who were blinded to the study protocol. If a fracture was detected, the adequacy of reduction was assessed.

Results The sensitivity of distal radius fracture diagnosis on ultrasound was 100% and specificity ranged from 90% to 95%. The sensitivity of identifying a satisfactory reduction ranged from 76% to 93% and specificity was 93% to 94%. Interrater reliability between the musculoskeletal radiologist and hand surgeon was $\kappa = 0.86$ for diagnosing the fracture and $\kappa = 0.82$ for identifying a satisfactory reduction. Intrarater reliability ranged from $\kappa = 0.82$ to 0.86.

Conclusions A pocket-sized, handheld diagnostic ultrasound device demonstrates the ability to diagnose distal radius fractures and assess fracture reductions. *(J Hand Surg Am. 2017;■(■):■–■. Copyright © 2017 by the American Society for Surgery of the Hand. All rights reserved.)*

Type of study/level of evidence Diagnostic II.

Key words Ultrasound, distal radius, trauma, reliability, diagnostic.

DISTAL RADIUS FRACTURES ARE ONE of the most common musculoskeletal injuries.[1,2] Emergency department (ED) management of closed and displaced distal radius fractures typically consists of closed reduction and placement of an orthosis followed by postreduction radiographs. Radiographic measurements, including radial height, radial inclination, and volar tilt of the distal radius, are used to assess the extent of fracture deformity and the quality of fracture reduction.[3] In some situations,

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particularly with non-orthopedists and in academic training programs, the initial attempt to reduce the fracture may be unsuccessful and will require another reduction attempt and postreduction radiographs. If available, fluoroscopy may be used to confirm a satisfactory reduction before radiographs. Studies have shown that radiographic imaging and fluoroscopy increases ED wait times and increases radiation exposure to patients.[4]

Ultrasound technology is regularly used in the ED setting to diagnose and treat a wide variety of diseases such as cardiac tamponade, intra-abdominal bleeding, abscesses, line placement, and obstetric assessment.[5] Four studies have evaluated the use of ultrasound to guide reductions of distal radius fractures.[6–9] These studies have shown that ultrasound-guided reductions have up to 94% sensitivity for detecting a successful closed distal radius fracture reduction and defined 3 standard views (longitudinally oriented dorsal, volar, and radial snuffbox).[6–9] Kodama et al[9] also found that ultrasound-guided reductions were equally capable of detecting successful reductions and were less costly than fluoroscopy-guided reductions. Those studies used large hospital-grade ultrasound machines that may be cumbersome and are costly. The studies also focused only on patients with fractures and did not evaluate healthy control subjects to determine whether ultrasound was sensitive in diagnosing a distal radius fracture.

Recently, pocket-sized handheld ultrasound devices have been developed that are portable, affordable, and simple to use. An ultrasound examination of the distal radius made with a pocket-sized device that can identify a satisfactory fracture reduction accurately has the potential benefit of reducing ED wait time, radiation exposure, and costs by decreasing the need for repeat radiographs and reductions. To date, however, no studies have evaluated whether a handheld, pocket-sized ultrasound can assess the degree of distal radius fracture deformity and the quality of fracture reduction.

The primary objective of this study was to evaluate the sensitivity and specificity of pocket-sized, handheld ultrasound in detecting distal radius fractures and satisfactory fracture reductions. Secondary outcomes include assessment of the interobserver and intraobserver reliability of pocket-sized, handheld ultrasound assessment for diagnosing a fracture and satisfactory reduction.

MATERIALS AND METHODS

We obtained permission from our institutional review board before commencing the investigation. Inclusion criteria for distal radius fracture patients included patients aged 18 years or older with acute (less than 48 hours) isolated, closed, displaced distal radius fractures that required fracture reduction. Patients with open fractures, polytrauma, and hardware in the distal radius from previous surgery of the wrist were excluded. Patients who were unable to undergo fracture reduction or sustained concomitant injuries preventing the application of ultrasound gel over the distal radius were also excluded. Inclusion criteria for healthy control subjects were individuals aged 18 years or older with no prior surgery or injury to the distal radius. Healthy control subjects were recruited from patients seen in the orthopedic hand clinic with wrist pain without a fracture.

Clinical procedures

All patients with distal radius fracture who met inclusion criteria and signed an informed consent were enrolled in the study. Radiographs were obtained to characterize the fracture. Displaced fractures were treated with closed reduction after a hematoma lidocaine injection was used for analgesia. The fractures were reduced with traction and manipulation followed by application of a sugar-tong orthosis. Postreduction x-rays were taken to assess the fracture reduction. Ultrasound examination of the distal radius fractures was performed before and after fracture reduction but before placement of an orthosis. Regardless of ultrasound findings, patients were placed in an orthosis and sent for postreduction x-rays.

Conventional radiographic criteria for unsuccessful reduction used in this study were defined as dorsal tilt greater than 0°, radial shortening greater than 3 mm, and coronal shift 1 mm or greater when reviewing postreduction radiographs. If reduction was deemed unsatisfactory on standard radiographs, the orthosis was removed and a repeat reduction was attempted until satisfactory reduction was achieved. Six patients required one repeat reduction.

Healthy control subjects underwent a one-time standard radiographic examination (posteroanterior, lateral, and oblique views) and one-time ultrasound examination (longitudinally oriented dorsal, volar, and radial snuffbox) of the distal radius.

All distal radius fracture reductions and ultrasound examinations for patients with fractures and control subjects were performed by a single operator throughout the duration of the study to eliminate variation in reduction and imaging techniques. The operator was an orthopedic surgery resident who had 1 year of radiology training. During this radiology