Diagnosing ulnar-sided carpometacarpal joint dislocation is difficult, and more than half of injuries are missed on initial examination. The authors hypothesized that measuring the angle between the capitate and the metacarpals (capitate-metacarpal angle) on a plain radiograph would provide a simple, reliable tool to aid in the diagnosis of ulnar-sided carpometacarpal dislocation. This study retrospectively reviewed patients who underwent surgery for ulnar-sided carpometacarpal dislocation (study group). Two authors identified the contour of the capitate and the second, fourth, and fifth metacarpals on plain radiographs. The control group consisted of patients who had radiographs and no bony carpal or metacarpal pathology. Information on the contour of each bone was entered into MATLAB, version 8.5, software (MathWorks, Natick, Massachusetts), which calculated the 2-dimensional angles. A 3-dimensional model based on computed tomography scan data was used to obtain a “true lateral” image to account for variable rotation on plain radiographs. With the use of conventional lateral hand radiographs, the average capitate-metacarpal angle in the control group was 10° compared with 19° in the study group. Using a screening value of 15° on plain radiographs, the sensitivity of the capitate-metacarpal angle was 0.85 and the specificity was 0.79. Both 2-dimensional and 3-dimensional measurements showed that the angle between the capitate and the lesser metacarpals is a reliable screening tool for carpometacarpal dislocation. During evaluation of patients with posttraumatic hand pain, an increased capitate-metacarpal angle may indicate the need for advanced imaging studies to further evaluate the carpometacarpal joints. [Orthopedics. 2017; 40(2):e352-e356.]

Ulnar-sided dislocation of the carpometacarpal joints is an uncommon injury that accounts for approximately 1% of hand-specific trauma. These injuries are specifically dislocations of the fourth or fifth metacarpal from its articulation with the hamate. These injuries are difficult to diagnose, and patients often present with subtle findings on physical and radiographic examination. Sequelae of missed or delayed diagnosis include long-term pain, arthritis, and decreased grip strength. Patients with delayed presentation are more likely to require an open procedure to prevent late complications, and the outcome for these patients is less favorable.

Current literature offers a few radiographic screening tools to assist in the diagnosis of carpometacarpal injury. However, inferior radiographs can limit the effectiveness of these techniques and may
play a role in the difficulty associated with diagnosing carpometacarpal injury. In acute hand injuries, the patient’s discomfort with certain positions or the radiograph technician’s experience can limit the ability to obtain a true posteroanterior or lateral radiograph. Fisher et al proposed looking at parallel M-lines on posteroanterior radiographs, where a break in parallelism indicates carpometacarpal joint disruption. These 2 lines, the first along the base of metacarpals 2 to 4 and the second along the distal ends of the trapezoid/capitate/hamate, can be difficult to identify and may be obscured by overlap of the hamate.

A more recent proposal by McDonald et al compared the angle between the small finger metacarpal and the index metacarpal. This method is highly dependent on obtaining a perfect lateral hand radiograph with overlap of the metacarpals while demonstrating the digits and phalanges without overlap. With varying rotation, pronation, or supination of the hand, it can be difficult to obtain a good lateral radiograph in the acute setting. Additionally, even with a “true lateral” radiograph, this technique may be challenging because of the difficulty in identifying the individual metacarpals, which are overlapping on radiographs. A reliable screening tool that could be used by both experienced clinicians and resident-level orthopedic or radiology trainees could reduce delays in diagnosis.

The goal of this study was to evaluate whether determining the relationship between the distal carpal row and the ulnar-sided metacarpal bones is a simpler and more reliable radiographic screening tool for ulnar-sided carpometacarpal dislocation than previously reported methods. The capitate is easily visible on lateral radiographs and should remain as a stable marker of the distal carpal row. The authors hypothesized that the capitate-metacarpal angle can be a reliable diagnostic tool, even without standardized true lateral radiographs.

**Materials and Methods**

After receiving institutional review board approval, the authors performed a retrospective chart review of their departmental database of all patients who underwent surgery for ulnar-sided carpometacarpal dislocation from 2003 to 2013. Within this initial operative group, all patients with posteroanterior and lateral radiographs and preoperative computed tomography (CT) scan of the hand or wrist were selected as the study group. Radiographs were obtained by conventional means, and no special instructions were given to radiograph technicians for obtaining a true lateral view. The control group consisted of patients treated during the same time period who had both CT scan and plain radiographs of the hand and wrist, but without evidence of bony carpal or metacarpal pathology, as determined by an attending radiologist. In the study group, 2 patients were excluded because of concomitant injuries to the capitate, and 1 was excluded because of existing hardware from a previous procedure.

For each patient, 1 senior-level orthopedic resident (V.C.P.) and 1 junior-level orthopedic resident (P.D.G.) outlined the bony contours of the capitate and the second, fourth, and fifth metacarpals by marking points on the periphery of each respective bone (Figure 1A). The investigators were blinded to whether the radiographs belonged to patients in the control group or the study group. The information was entered into MATLAB, version 8.5, software (MathWorks, Natick, Massachusetts), which identified the longitudinal axis of each bone (Figure 1B) and calculated the capitate-metacarpal angle (Figure 1C) for both the fourth metacarpal-capitate and the fifth metacarpal-capitate to measure the authors’ technique. Additionally, tracing data were used to calculate the angle between the long axes of the second and fifth metacarpals, or the intermetacarpal angle, and the findings were compared with the technique of McDonald et al.

To account for variability on lateral plain radiographs and validate the findings of the 2-dimensional measurements, CT scan was used to recreate 3-dimensional reconstructions. The Digital Imaging and Communications in Medicine information from each patient’s CT scan was entered into Mimics, version 18.0, software (Materialise NV, Leuven, Belgium) to generate separate geometric files. Each 3-dimensional model was smoothed to reduce the pixelated effect of segmentation (Figure 2). The 3-dimensional model was then used to obtain a sagittal plane image that would represent a true lateral radiograph.
radiograph view. With the use of this true lateral image based on the CT reconstruction (Figure 2C), the capitate-metacarpal angle and the intermetacarpal angle were then calculated in similar fashion to the 2-dimensional images (Figure 1C).

Statistical analysis was performed with Student’s t test to compare the study group and the control group, based on both the lateral 2-dimensional radiograph and the 3-dimensional reconstruction. Statistical significance was set at $P<0.05$. An intraclass correlation coefficient was used to determine interobserver reliability between corresponding continuous numeric values. A scatter plot analysis was performed to determine an appropriate division between normal and abnormal angles for use as a screening tool for carpometacarpal dislocation. The results were then compared with those of McDonald et al.9

**RESULTS**

The study group consisted of 10 men with 18 ulnar-sided carpometacarpal dislocations. Of these patients, 8 had injuries to the fourth and fifth carpometacarpal joints on the same hand, 1 had an isolated fourth carpometacarpal dislocation, and 1 had an isolated fifth carpometacarpal dislocation. The mechanism of injury was fall in 5 patients (50%), direct blow in 4 patients (40%), and crush injury in 1 patient (10%).

Average capitate-metacarpal angle in the control group was 10° (range, 2°-21°) compared with 19° (range, 9°-29°) in the study group ($P<0.01$). According to the method of McDonald et al,9 the intermetacarpal angle between the second and fifth metacarpals was calculated in the control group as 8° (range, 4°-23°) compared with 13° (range, 0°-25°) in the study group ($P=0.08$).

When the 3-dimensional reconstructions were used to obtain a true lateral sagittal plane image, the capitate-metacarpal angle was 20° (range, 9°-32°) in the control group compared with 26° (range, 9°-33°) in the study group ($P<0.01$). The intermetacarpal angle between the second and fifth metacarpals was 24° (range, 16°-30°) in the control group and 28° (range, 20°-34°) in the study group ($P<0.01$).

A scatter plot analysis was constructed for all 2-dimensional measurements between the study group and the control group (Figure 3). A division at 15° was chosen for the screening value between a normal carpometacarpal joint and a dislocated carpometacarpal joint. With this screening value, sensitivity was 0.85 and specificity was 0.79 for the capitate-metacarpal angle. When the second to fifth intermetacarpal angle method was applied to the patient population and radiographs with the 10° cutoff, sensitivity was 0.64 and specificity was 0.66.

Interobserver reliability was calculated with a mean intraclass correlation coefficient. Mean intraclass correlation was 0.93 for the capitate to fourth metacarpal angle, 0.95 for the capitate to fifth metacarpal angle, and 0.93 for the second to fifth intermetacarpal angle.

**DISCUSSION**

Dislocations at the carpometacarpal joint result in noticeable swelling over the dorsum of the hand, making physical diagnosis difficult because there are often no obvious signs of joint dislocation. Additionally, the findings of standard radiographs are often inconclusive because on the posteroanterior view the carpometacarpal joints are obstructed by overlap of the hamate and on the lateral view visualization is obscured because of metacarpal overlap and difficulty determining the contours of the hamate.11 Additionally, the high variability in the rotation and quality of lateral radiographs makes the injury difficult to visualize. Retrospective studies showed that more than 60% of these injuries may not be detected on initial assessment. Lawlis and Gunther2 noted that 15 of 21 injuries were missed initially. Pullen et al1 found similar results, with 8 of 13 patients presenting with a delay in diagnosis.

A delay in the diagnosis of carpometacarpal dislocation can result in greater morbidity and increased need for open reduction.7,8 Some recommend obtaining oblique radiographs at 30° to 45° when this injury is suspected.12,13 Fisher et al16 proposed reviewing posteroanterior radiographs for identification of the parallel M-lines that follow the contour of the distal carpal row along the trapezoid, capitate, and hamate to check for joint symmetry.
Unfortunately, this method is not ideal because the typical carpometacarpal dislocation is in the dorsal direction, which is parallel to the plane of a posteroanterior radiograph. Use of CT scan or other advanced imaging methods is often needed to obtain an accurate representation of the carpometacarpal joints, but patient care often is not escalated to a more experienced physician who can recommend such examinations.

A more recent proposal by McDonald et al compared the angle between the small finger metacarpal and the index metacarpal. Although their method was more sensitive and specific than those previously described, identification of the index and middle metacarpals is often difficult, especially when the hand is poorly positioned for the lateral radiograph. Additionally, variability in lateral radiographs may change the proposed screening angle of 10°. Because angle measurement is based solely on the index and small metacarpals, any patient with concomitant second, third, or fourth metacarpal fractures requires a different screening method.

In the setting of ulnar-sided carpometacarpal dislocation, the relative angle between the longitudinal axis of the capitate and the fourth and fifth metacarpals is increased, providing an effective screening method for these injuries, which can be difficult to diagnose. Use of the capitate as an easily identified landmark on lateral radiographs allows this method to be used even if multiple metacarpals are affected. Additionally, any radial or ulnar deviation of the fingers should not affect the angle measurement based on a lateral radiograph.

Use of the capitate as a reference can eliminate much of the confusion associated with carpometacarpal injuries. The current results showed statistical significance for both clinical lateral radiographs and true lateral 3-dimensional reconstruction, suggesting that rotation of lateral radiographs has little effect on the capitate-metacarpal angle. A similar trend is seen on CT evaluation. This study used a computer-assisted method to measure the angles for internal validation. However, in the clinical setting, the angles are readily measured with a standard goniometer or an angle tool on any digital image viewing software.

**Limitations**

This study had several limitations. Because the study was retrospective and these injuries are relatively uncommon, it is difficult to determine the true effectiveness of the proposed screening method and the percentage of missed injuries with the use of these parameters. Additionally, the methods presume nominal flexion and extension of the second through fifth metacarpals, although evidence shows that minimal sagittal plane carpometacarpal motion occurs. The scarcity of ulnar-sided dislocations makes true outcome measurements difficult to determine. Although this study included patients treated during a 10-year time frame, the strict inclusion criteria of only operatively treated carpometacarpal dislocations limited the number of patients in the study group. The study data showed that the average capitate-metacarpal angle in the injured study group was approximately 9° greater than that in the control group. However, the reported sensitivity of 0.85 with a 15° screening value shows that use of this method alone can result in false-negative findings. Therefore, this method must be accompanied by a thorough history and physical examination to increase its usefulness.

**Conclusion**

The capitate-metacarpal angle is recommended as a screening tool for carpometacarpal injury. It can help the clinician to evaluate patients with inconclusive findings on physical examination, dorsal hand swelling, and ulnar-sided hand pain. If the angle is greater than 15°, then advanced imaging should be considered because reduction and stabilization of the dislocation may be needed.
REFERENCES


