The Intermetacarpal Angle Screening Test for Ulnar-sided Carpometacarpal Fracture-Dislocations

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Purpose Ulnar-sided carpometacarpal injuries can be difficult to diagnose radiographically. We hypothesized that the resting position of the normal hand during lateral radiography provides a consistent relationship between the rays and that dorsal subluxation of the metacarpal base in fracture-dislocations increases the angle between the uninjured index and long metacarpals and the injured small metacarpal.

Methods A control group of 100 consecutive patients with normal hand radiographs and a series of 12 patients with known carpometacarpal fracture-dislocations were examined. Angles between the index and small metacarpal shaft (I-S IMA) and between the long and small metacarpal shaft (L-S IMA) were measured on the lateral hand radiograph.

Results In the control group, the mean I-S IMA and L-S IMA were both 6°. In the study group, the mean I-S IMA was 18°, and the mean L-S IMA was 16°. Intraobserver and interobserver reliability was good to excellent for both groups, and a statistical difference existed between the normal and study groups. Based on box-plot analysis of normal and abnormal IMAs, a natural dividing line existed at 10°. With this dividing line, the I-S IMA had a sensitivity of 92% and a specificity of 81%, and the L-S IMA had a sensitivity of 83% and a specificity of 84%.

Conclusions Both the I-S IMA and the L-S IMA were useful screening measurements on lateral hand radiographs for detection of ulnar-sided carpometacarpal fracture-dislocations. When evaluating posttraumatic ulnar-sided hand pain, advanced imaging should be considered if the I-S IMA or the L-S IMA is greater than 10°. (J Hand Surg 2012;37A:1839–1844. Copyright © 2012 by the American Society for Surgery of the Hand. All rights reserved.)

Type of study/level of evidence Diagnostic III.

Key words Carpometacarpal dislocation, carpometacarpal fracture-dislocation, clenched fist injury, metacarpal fracture.

Injuries to the carpometacarpal joints are common; however, our literature review yielded few case reports and case series involving this area.1–19 Publications from the 1940s identified only 83 cases, although a third of these were dislocations of all of the ulnar carpometacarpal joints.12 Particular concern, however, was paid to injuries of the base of the ring and small metacarpals, although no method for diagnosis was provided other than radiographic evaluation “by one who has a thorough knowledge of the anatomy of the carpus.”12 More recent literature from the 1980s identified more than 60 additional cases,5 and a case report in 2011 highlighted a missed carpometacarpal fracture-dislocation.14
These injuries are easily overlooked due to a paucity of obvious physical examination and radiographic findings, causing a delay in diagnosis. Most carpometacarpal joint injuries occur at the hamatometacarpal joint, and the majority are dorsal fracture-dislocations rather than simple dislocations (Fig. 1). The ring and small finger metacarpals have a saddle configuration with the hamate, allowing increased mobility compared to the rigid carpometacarpal joints of the index and middle fingers. Studies by Henderson and Arafa and by Lawlis and Gunther noted that 15 of 21 injuries were initially missed, and a later series by Pullen et al found that 8 of 13 cases presented with a delayed diagnosis. The senior author (L.T.K.) found that 4 of 7 large fragment coronal split fractures of the hamate with carpometacarpal fracture-dislocations were missed by the initial treating physician. In reviewing these lateral plain radiographs it was evident that the alignment of the small metacarpal was not congruent with the normal palmar arch.

The purpose of this study was to review lateral radiographs of uninjured hands to define the normal intermetacarpal angles between the index and small metacarpals (I-S IMA) and the long and small metacarpals (L-S IMA), and then compare them to the same angles on individuals with known ulnar-sided carpometacarpal fracture-dislocations. The small finger metacarpal rather than the ring finger metacarpal was chosen because it is more consistently involved in these injuries. We hypothesized that there would be a significant difference in the intermetacarpal angles of patients with dorsal subluxation of the metacarpal base in fracture-dislocations compared to a control group of patients with normal lateral hand radiographs. We hoped to develop a simple screening tool to identify ulnar-sided carpometacarpal fracture-dislocations that would warrant advanced imaging and early treatment.

**MATERIALS AND METHODS**

Institutional review board approval was obtained before the start of this investigation. Two groups of patients were identified. The subject population included all patients greater than 18 years of age who had sustained carpometacarpal fracture-dislocations at the hamate between July 2004 (when the senior author [L.T.K.] began treating these injuries at our institution) and April 2010. These were documented by plain radiographs and confirmed by computed tomography or during surgical fixation. Due to the lack of previous background data on this subject, no *a priori* power analysis could be performed. To combat this, we consulted a biomedical statistician who, based on accepted community standards, recommended a cohort of 100 consecutive control subjects to determine the normal intermetacarpal angle. These subjects were all greater than 18 years old and had normal lateral hand radiographs. Radiographs were identified in our tertiary referral center’s digital radiography system and included all radiographs ordered by any medical provider. All radiographs were interpreted as normal by a musculoskeletal fellowship-trained radiologist. Data for this control group were collected from January 2010 until April 2010. Patients younger than age 18 years and patients with documented injuries (new or old) to the hand, wrist, or forearm bones were excluded.

To identify study patients, the surgical database was queried for all Current Procedural Terminology codes involving the carpometacarpal joint. Surgeon case logs were also reviewed to identify these injuries. Finally, the same cohort of patients with coronal split hamate fractures identified in our earlier study were included as part of the study group. A retrospective review of clinic charts, radiographic imaging within our digital imaging system, and administrative files was undertaken.

Lateral hand and wrist radiographs often vary in quality. Criteria for high-quality lateral wrist radiographs often vary in quality. Criteria for high-quality lateral wrist radiogra-
phy include viewing the pisiform lying midway between the anterior scaphoid cortex and the capitate head. Standards for hand radiography are less well defined, with a goal of overlying metacarpals while demonstrating the digits without any overlap. These radiographs can have variable degrees of metacarpal overlap with positions of pronation and supination. In this study, all lateral radiographs were considered, regardless of quality, because it was a good representation of what actually occurs in primary care and emergency evaluations of orthopedic conditions. Although palmar concavity changes along the metacarpals, this was not the focus of our evaluation, and only the angles between the metacarpals in question were evaluated.

The separate longitudinal axes of the metacarpal shafts can be superimposed on the lateral view and difficult to determine. The index, long, and small finger metacarpals were identified by the observers using the length of the metacarpal and the fanned finger position on the lateral hand radiograph. Observers individually drew best fit-lines down the center of the medullary canal of the index, long, and small metacarpals. The angles between the index and small finger metacarpal and between the middle and small finger metacarpal were measured using the angle measurement tool within the digital radiograph system, and these were recorded on the data collection sheet (Figs. 2, 3). A fellowship-trained hand surgeon, a senior orthopedic surgery resident, and a junior orthopedic surgery resident performed all measurements. Repeat evaluations were performed 2 weeks later, allowing for both interobserver and intraobserver evaluations.

Intraobserver reliability and interobserver reliability were calculated for both the I-S IMA and the L-S IMA. Both the \( t \)-test and the Mann-Whitney U rank sum test were used to compare the normal cohort with the known abnormal cohort to determine whether there were indeed statistical differences between the groups. Box-plot analyses were used to determine where a divide could be drawn between normal and abnormal intermetacarpal angles. Because there is no published normal intermetacarpal angle, prestudy power analysis could not be performed.

RESULTS
The control group consisted of 65 men and 35 women with 68 right hand radiographs and 32 left hand radiographs. The ulnar-sided carpometacarpal fracture-dislocation group consisted of 12 men and no women. All injuries occurred on the dominant extremity from an axial load injury (ie, clenched fist injury), 11 of which were the right hand.

For the control group, the mean I-S IMA and the mean L-S IMA were both 6° (SD 4). For the ulnar-sided carpometacarpal fracture-dislocation group, the mean I-S IMA was 18° (SD 7), and the mean L-S IMA was 16° (SD 6).

Both the \( t \)-test and the Mann Whitney U rank sum test found a statistical difference between the I-S IMA and L-S IMA of normal and abnormal radiographs with \( P \) values of <.01. Intraobserver reliability was good to excellent, ranging from 0.72 to 0.90 for the I-S IMA and from 0.68 to 0.91 for the L-S IMA. Interobserver reliability was also good to excellent and varied from 0.79 to 0.90 for the I-S IMA and was consistent at 0.84 for the L-S IMA.

Based on box-plot analysis of control group and injury group, a natural dividing line existed at approximately 10° for both the I-S IMA and the L-S IMA (Figs. 4, 5). When using this value, the I-S IMA had a sensitivity of 92% and a specificity of 81%, whereas the L-S IMA had a sensitivity of 83% and a specificity of 84%.
Ulnar-sided carpometacarpal dislocations and fracture-dislocations are often missed in the primary care or emergency setting due to the complexity of reading lateral hand radiographs. In evaluating ulnar-sided carpometacarpal fracture-dislocations, lateral radiographs are the best method of demonstrating the injury. Some authors recommend adding a 30° to 45° pronation oblique image to evaluate for ring and small carpometacarpal joint injuries following axial load injuries. At our institution, emergency room physicians and primary care providers do not routinely use this view for screening these injuries. Radiology literature recommends using a complicated approach of reviewing posteroanterior radiographs, identifying parallel M lines (proximally following the curvatures of the distal trapzoid, capitate, and hamate while distally following the base of the index through small metacarpals), checking for joint symmetry, evaluating the cortical rims, and determining the ulnar deviation of the fifth metacarpal. They also recognize that, in carpometacarpal injuries, the longitudinal axis of involved metacarpals does not parallel the axis of uninvolved metacarpals.

We found that both the I-S IMA and the L-S IMA were useful screening measurements on the lateral hand radiograph, without the need for special positioning to detect carpometacarpal fracture-dislocations. The long metacarpal was often the easiest to determine on a lateral hand radiograph because it projects furthest distally. Therefore, we expected to find this the better of the angles for a screening tool. Although the L-S IMA demonstrated better specificity, the I-S IMA demonstrated better sensitivity. Regardless, both the I-S IMA and the L-S IMA had adequate sensitivity and specificity to be used as screening tools to evaluate posttraumatic ulnar-sided hand pain. Because the middle finger metacarpal is easier to identify on lateral hand radiographs, we recommend use of the L-S IMA on lateral hand radiographs when screening for ulnar-sided carpometacarpal fracture-dislocations.

FIGURE 3: Lateral radiograph demonstrating the I-S IMA of a ulnar-sided carpometacarpal fracture-dislocation and an intermetacarpal angle greater than 10°. The index finger metacarpal is outlined in dark blue, and the small finger metacarpal is outlined in light blue. The white arrow denotes a carpometacarpal fracture-dislocation at the small finger. Best-fit lines down the metacarpal shafts are the red, parallel lines. In this injured hand radiograph, the I-S IMA is 14°.

DISCUSSION

Ulnar-sided carpometacarpal dislocations and fracture-dislocations are often missed in the primary care or emergency setting due to the complexity of reading lateral hand radiographs. In evaluating ulnar-sided carpometacarpal fracture-dislocations, lateral radiographs are the best method of demonstrating the injury. Some authors recommend adding a 30° to 45° pronation oblique image to evaluate for ring and small carpometacarpal joint injuries following axial load injuries. At our institution, emergency room physicians and primary care providers do not routinely use this view for screening these injuries. Radiology literature recommends using a complicated approach of reviewing posteroanterior radiographs, identifying parallel M lines (proximally following the curvatures of the distal trapzoid, capitate, and hamate while distally following the base of the index through small metacarpals), checking for joint symmetry, evaluating the cortical rims, and determining the ulnar deviation of the fifth metacarpal. They also recognize that, in carpometacarpal injuries, the longitudinal axis of involved metacarpals does not parallel the axis of uninvolved metacarpals.

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Literature on long-term sequelae for missed diagnosis is sparse, although in nonreduced injuries, degenerative arthritis, weakness of power grip, and decreased motion is well documented. Lawlis and Gunther’s review of their carpometacarpal injuries found that, of those treated with open or closed reduction or immediate arthrodesis, 16 of 19 had satisfactory to excellent outcomes. The single patient who presented late with a missed carpometacarpal fracture-dislocation opted for no further treatment and had an unsatisfactory outcome.

Weaknesses of the study include the inability to perform an a priori power analysis, given the lack of previous background data. We based our reference group size on community standards, although further studies could evaluate more uninjured lateral hand radiographs to better define normal. There was no standardized positioning for radiographs, and developing a frame to place all hands into before taking lateral hand radiographs would likely improve reproducible lateral hand radiographs. This might provide more consistency; however, the resting position of the hand and internal referencing of the angles provide consistent measurements of intermetacarpal angles. Further, perfect positioning of the acutely injured hand for radiographic imaging can be quite difficult due to swelling that obscures reference landmarks.

In addition, identification of the index and middle finger metacarpals can be challenging, especially in cases with complete overlap and poor positioning of the hand. Because both the I-S IMA and the L-S IMA are effective screening tools, future studies could consider...
evaluating a summation angle for the index and middle finger metacarpals with the small finger metacarpal for cases in which the metacarpal axis cannot be differentiated on the lateral hand radiograph.

We also recognize that there is large variability in the intermetacarpal angles for the control group of normal radiographs, with a standard deviation of 5°. Despite this, there remains a statistical difference between both the I-S IMA and the L-S IMA for normal radiographs and known ulnar-sided carpometacarpal fracture-dislocations. Future directions for study could also include evaluating the specific effects of pronation and supination of the forearm on the intermetacarpal angle in uninjured hands.

Although the findings of this study do not set concrete rules, they do provide guidelines when evaluating lateral hand radiographs taken for posttraumatic ulnar hand pain to rule out ulnar-sided carpometacarpal fracture-dislocations. If the L-S IMA is greater than 10°, one should consider a carpometacarpal fracture-dislocation and possibly obtain a computed tomography scan.

REFERENCES