SCIENTIFIC ARTICLE

Correlation of the Lateral Wrist Radiograph to Ulnar Variance: A Cadaveric Study

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Purpose Both positive and negative ulnar variance have been implicated in a variety of wrist disorders. Surgery aims to correct the variance in these pathologic conditions. This necessitates accurate and reproducible measuring tools; however, the most accurate radiographic measurement technique remains unclear. The purposes of this study were to evaluate 3 methods for determining ulnar variance and to compare each with direct anatomic measurement in a cadaver model.

Methods We fixed 10 fresh above-elbow cadaver specimens in neutral rotation and obtained standardized fluoroscopic posteroanterior and lateral wrist images. A dorsal approach was performed and two independent investigators directly measured ulnar variance using digital calipers with the cartilage both intact and denuded. Ulnar variance was measured radiographically using the lateral, perpendicular, and central reference point methods. The reliability of each set of measurements (within a 1-mm cutoff) was assessed by the intraclass coefficient; agreement between radiographic and direct measurements was evaluated by the Bland–Altman method.

Results Each method of determining ulnar variance demonstrated near perfect agreement by the intraclass coefficient. The lateral radiograph method correlated highly with the directly measured ulnar variance with the cartilage denuded with an average measurement difference of 0.06 mm. No radiographic measurement technique demonstrated consistent agreement within 1 mm of the measured ulnar variance with the cartilage intact.

Conclusions Ulnar variance measured by the lateral wrist radiograph technique correlates highly with the directly measured osseous ulnar variance. The remaining measurement techniques did not correlate reliably to within 1 mm of the directly measured ulnar variance with 95% confidence. No method was able to account accurately for the articular cartilage thicknesses at the lunate facet of the radius or the distal ulnar head, which we found to vary in an unpredictable manner. Whereas the lateral radiograph has been shown to allow for more reliable standardization of wrist position compared with the posteroanterior view, this study also highlights the inherent limitations of using static radiographic images in evaluating ulnar variance.

Clinical relevance The results of the current study demonstrate the utility of the lateral wrist radiograph for assessing bony ulnar variance. *(J Hand Surg Am. 2018;■(■):1.e1-e9. Copyright © 2018 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Articular cartilage, lateral radiograph, triangular fibrocartilage complex, ulnar variance, wrist.

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Ulnar variance describes the difference in height between the lunate facet of the distal radius and the distal ulnar head. Variation in this measurement has the potential to alter biomechanical loading of the wrist[1]; thus, ulnar variance has been implicated as a factor in a variety of degenerative and traumatic disease states such as triangular fibrocartilage complex (TFCC) tears,[2,3] Kienböck disease,[4–6] ulnocarpal impaction,[7,8] radioulnar impingement,[9–11] radioulnar-carpal instability,[12–14] scaphoid fracture,[15] nonunion,[16,17] and distal radius malunion.[18,19] Given these observations, various surgical procedures have been employed to alter ulnar variance in an attempt to modify loading profiles and alleviate pain.

Reliable measurements of ulnar variance are important to surgical correction, yet the preferred method of measurement remains uncertain. Several methods have been proposed, including the project-a-line,[4] concentric circles,[20] perpendiculars,[21] and central reference point (CRP) methods.[22] A previous investigation by Steyers and Blair[23] found minimal clinical difference among the first 3 methods listed and concluded that each was suitable for determining ulnar variance. However, each of these measurements is derived from the posteroanterior (PA) radiograph, the standardization of which may be limited by technique and patient-dependent variability. For example, volar-dorsal tilt is affected by the relative size of the soft tissue envelope surrounding the proximal forearm as the patient rests this and the palm on the x-ray plate. The larger the soft tissue envelope surrounding the forearm, the more volar tilt is imparted upon the projection of the resting wrist (Fig. 1). In addition, the effect of pronosupination on ulnar variance may be difficult to standardize as the ulna lengthens relative to the radius with pronation (greater ulnar variance) and shortens relative to the radius with supination (smaller ulnar variance).[24] Exact neutral rotation, defined by the groove of the extensor carpi ulnaris positioned immediately radial to the ulnar styloid, may be difficult to identify with precision because these structures may be more or less pronounced based on normal anatomic variation.[24] Finally, the nadir of the lunate fossa, which articulates with the most proximal aspect of the lunate, is frequently inadequately visualized, which introduces the potential for overestimation of the radial length relative to the ulnar length.

Measuring ulnar variance from the lateral wrist radiograph offers several potential advantages, including improved visualization of the lunate fossa and distal ulnar head geometries, while allowing for easier control of radioulnar tilt (because the arm is rested on the subcutaneous border of the ulna, which remains subcutaneous regardless of patient size, instead of the muscle belly of the flexor-pronator mass, which can have a large amount of individual variability and therefore change the projection with a PA view) and pronosupination (with neutral wrist position defined by overlap of the radial and ulnar shafts, centering the volar cortex of the pisiform between the volar cortex of the distal scaphoid pole and the convexity of the proximal capitate, and the third metacarpal, capitate, lunate, and distal radius axis remaining collinear).[22,25] Despite this, the PA view remains most commonly used to measure ulnar variance, likely because it offers easier simultaneous visualization of the radius and ulna next to one another. Admittedly, the lateral view relies on overlapped projections of these 2 bones, which requires familiarity with interpreting anatomy in a different perspective.

Recently, Parker et al[25] confirmed the reliability of measuring ulnar variance from the lateral radiograph as well as from the PA radiograph via the method of perpendiculars and CRP; however, each method yielded different measurement values with no reference standard for comparison. Therefore, the purpose of this investigation was to evaluate radiographic ulnar variance measurements using the lateral view, perpendiculars, and CRP methods compared with direct anatomic measurements in cadaveric specimens. We hypothesized that because of more recognizable anatomic landmarks and potentially less error related to parallax, the lateral wrist radiograph would provide the most accurate assessment of ulnar variance.

MATERIALS AND METHODS

Ten fresh-frozen cadaver upper extremities with all soft tissue structures intact were obtained with each extending above the elbow. Five left-sided and 5 right-sided specimens from 10 separate cadavers were used. Mean age at time of death was 72 years (range, 48–90 years); there was an equal sex distribution. Standardized PA and lateral fluoroscopic images were obtained of each wrist with the focal point distance and location held constant at 44 cm. To allow for variations that would be encountered in clinical practice, no attempt was made to correct for differences in the soft tissue envelopes among specimens. A 10-cm radiographic marker was placed directly onto the plate immediately adjacent to the wrist (consistent with standard clinical practice when