

Madelung's Deformity: Quantitative Assessment of X-Ray Deformity

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Purpose: To evaluate 5 defined measurement techniques that are applicable to x-rays of Madelung's deformity: ulnar tilt, lunate subsidence, lunate fossa angle, palmar tilt, and palmar carpal displacement. The measurements rely on the longitudinal axis of the ulna and the carpal bones to determine drawing lines and avoid the distorted distal radius and its deformed lunate fossa. The reliability and reproducibility of the measurements is determined.

Methods: Forty-eight sets of posteroanterior and lateral x-ray views of the wrist of subjects with the clinical diagnosis of Madelung's deformity were measured by 4 raters. Each rater made the 5 defined measurements on each pair of x-rays. Pairs of raters were compared for reliability using the Pearson correlation coefficient and Lin's concordance correlation coefficient. Two raters repeated the 4 reliable measurements a minimum of 6 months after the first measurements. Each rater's results were compared for reproducibility using Lin's concordance correlation coefficient.

Results: Ulnar tilt and lunate subsidence have excellent reliability and reproducibility. Palmar carpal displacement has acceptable reliability and reproducibility. Lunate fossa angle has borderline reliability but excellent reproducibility. Palmar tilt has poor reliability.

Conclusions: Ulnar tilt, lunate subsidence, and palmar carpal displacement, as defined, are considered reliable and reproducible measurements for quantifying the severity of Madelung's deformity on x-rays. Lunate fossa angle is not sufficiently reliable for comparing preoperative and postoperative wrists but may prove useful in establishing an early diagnosis. Palmar tilt is not measured reliably on a lateral x-ray because of the superimposition of multiple structures on a lateral x-ray and the absence of the volar part of the lunate fossa in patients with severe Madelung's deformity. Advanced imaging techniques are needed to delineate the deformity of the distal radius in a lateral projection. (*J Hand Surg* 2005;30A:1211-1220. Copyright © 2005 by the American Society for Surgery of the Hand.)

Type of study/level of evidence: Diagnostic, Level II.

Key words: Madelung, deformity, x-ray, reliability, measurement.

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Madelung's deformity is caused by premature closure of the physis of the distal radius in its volar ulnar segment.¹⁻⁴ It is more common in females, often is associated with dyschondrosteosis, and produces visible deformity at adolescence. It is characterized by increased ulnar and palmar tilting of the distal radius articular surface, palmar bowing of the distal radius, and relative overgrowth of the distal ulna. Although it is usually bilateral the severity of the deformity is not usually symmetric. Several researchers have reported surgical procedures designed to correct the deformity.⁵⁻¹⁵

Most reports of surgical procedures provide results that compare the preoperative and postoperative ranges of motion of the forearm and wrist, improvement in appearance of the deformity, relief of pain, and the satisfaction of the patient and family.^{6-10,12,16} This is in sharp contrast to reports of the correction of other distal radius deformities; although these include similar data they also provide quantitative measurements of the deformity.^{17,18} These measurements allow comparison of the degree of severity of the original deformity with the postoperative correction. None of the reports of Madelung's deformity document that the severity of pain, altered range of motion, or visual deformity correlate with the degree of bony deformity. To study these possible correlations a technique of quantitative measurement is necessary.

Several researchers have defined measurements based on the distal radius that attempt to quantify the degree of Madelung's deformity; however, none of these has been shown to be reliable or reproducible,^{7,10-13,19} principally because the distal radius in severe Madelung's deformity is so distorted that the usual landmarks²⁰ are difficult to identify and measure. The bowing of the distal radius makes the longitudinal axis of the radius an arc rather than a straight line. The distortion of the lunate fossa makes it impossible to establish convincingly a point that represents the ulnar margin of the radius.

In an attempt to quantify the bony distortion of Madelung's deformity the senior author (H.R.M.) developed and tested several measurements. Techniques were defined that measure the angle of the articular surface of the radius on posteroanterior (PA) and lateral x-rays, the slope of the abnormal lunate fossa, the amount of relative overgrowth of the ulna, and the bow of the distal radius (McCarroll HR, presented at the Second International Workshop on Congenital Differences of the Upper Limb, 1994).²¹

Several definitions were discarded as not being useful and were not otherwise tested.

The proposed measurement techniques differ from other measurements of Madelung's deformity because they rely on the ulna rather than the radius as a reference. Because the ulna is not primarily affected by Madelung's deformity and is frequently nearly normal in shape the underlying principle of the proposed definitions is the use of the longitudinal axis of the distal ulna as a baseline for the measurements. Most of the proposed measurements also use the surfaces of the carpal bones rather than the articular surface of the radius to define measured distances and angles.

Materials and Methods

Study Design

The records of patients of the Shriners Hospital for Children Northern California and of the senior author's (H.R.M.) private practice were reviewed and patients with a diagnosis of Madelung's deformity were identified. The retrospective review of Shriners Hospital for Children Northern California records for the purposes of this study was approved by the University of California-Davis institutional review board. The diagnosis of Madelung's deformity was based on family history, clinical examination, and x-rays of the wrists. The mother and grandmother of patients with Madelung's deformity frequently had x-rays available in the patient's file; these were included in the pool examined for suitable x-rays. All patients at the Shriners Hospital are younger than 21 years; the x-rays of the family members allowed us to include older people in the study. The requirements for inclusion in the study were a diagnosis of Madelung's deformity, as established by experienced hand surgeons at a major pediatric orthopedic hospital, and the availability of satisfactory preoperative PA and lateral x-rays of the wrist and distal third of the forearm. To test the defined measurement techniques, a broad spectrum of severity is highly desirable. Thus, when satisfactory views of the contralateral forearm were available that set was included in the study regardless of the degree of involvement.

Forty-eight sets of x-rays met the criteria and were included in this study. The x-rays represent 26 patients; 22 patients had x-rays of both upper extremities included in the study. The cohort included 23 female and 3 male patients. The age range was 8 to 52 years (average age, 23 y). Because several skeletally immature, teenage patients were evaluated by

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