Compared With Magnetic Resonance Imaging, Radiographs Underestimate the Magnitude of Negative Ulnar Variance

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Abstract

It is unclear how to interpret ulnar variance (UV) as determined by magnetic resonance imaging (MRI).

Using a radiology database, we retrospectively assessed UV on MRI and compared it with UV on radiographs. MR images of 163 wrists (158 patients) were reviewed. Mean (SD) UV was –0.16 (2.43) mm on radiographs, –0.62 (2.41) mm on T_1-weighted (bone-to-bone) MRI, and –0.50 (2.38) mm on gradient-echo or short tau inversion recovery (cartilage-to-cartilage) MRI. Compared with MRI, radiographs significantly underestimated the magnitude of negative UV. There was no difference in UV between different hand positions in MRI.

Further research is needed to validate the measurement of UV on MRI and to determine its clinical utility.

The relation between ulnar height and the carpus alters wrist biomechanics[1] associated with changes in subchondral bone composition.[2] Moreover, changes in ulnar variance (UV) have been associated with a wide spectrum of wrist pathologies, from bony problems, including Kienböck disease,[3] to ligamentous problems, including distal radioulnar joint and intercarpal and triangular fibrocartilage complex (TFCC) lesions,[4-6] to extra-articular pathologies, including extensor tendon ruptures.[7] UV can be measured with different radiographic methods[8,9] and varies with shoulder, elbow, wrist, and hand positions.[10-13] Despite the difficulties in obtaining accurate values, UV determination remains a useful clinical tool in hand surgery.

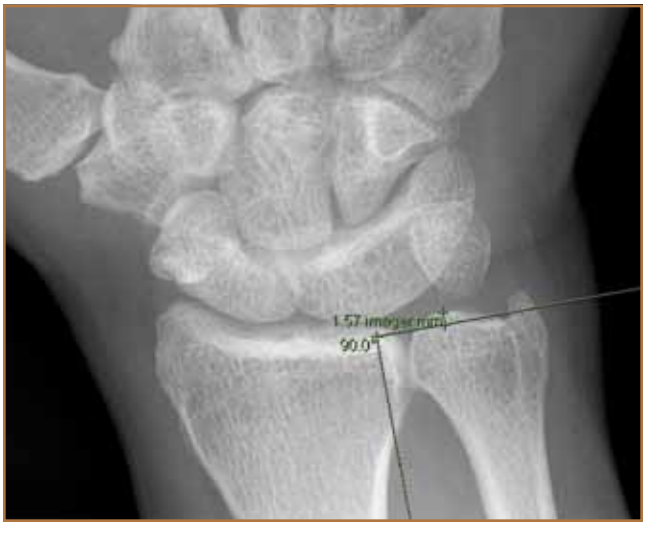
According to our literature review, no standardized methodology has been developed to measure UV on magnetic resonance imaging (MRI). Many of the pathologies affected by UV (eg, Kienböck disease, TFCC lesions) are commonly imaged with MRI. In formulating treatments, it would be useful to be able to reliably evaluate UV from MRI without additional studies. Furthermore, judgments may be based on UV as projected on MR images, and clinicians may be unaware if MRI-visualized variance corresponds to variance on standardized plain radiographs.

We conducted a study to determine if UV measured on MRI corresponds to UV measured on plain radiographs. The secondary aim of this study was to determine if there is a simple, accurate, and reliable method for determining UV on MRI.

Materials and Methods

A radiology database was retrospectively reviewed to select adult patients with hand or wrist MRIs performed at our hospital between 2006 and 2010. These patients' records were examined to determine if a radiograph had been taken of the ipsilateral hand or wrist. The hospital's radiology department had standardized protocols for shoulder and elbow positioning for wrist and hand radiographs in place during this study. Patients with marked dysplasias, previous fractures disrupting the lunate facet or the ulnar head, or hardware adjacent to the wrist, such that an MR image would be difficult to interpret, were excluded. In addition, patients without standardized po-

Figure 1. UV determination on radiographs using project-a-line technique.



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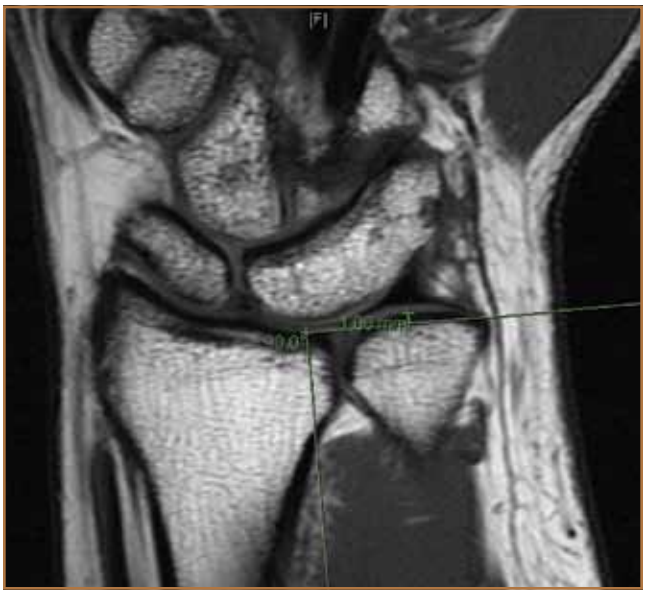

Figure 2. UV determination on T_1-weighted MRI using project-a-line technique measuring bone to bone.

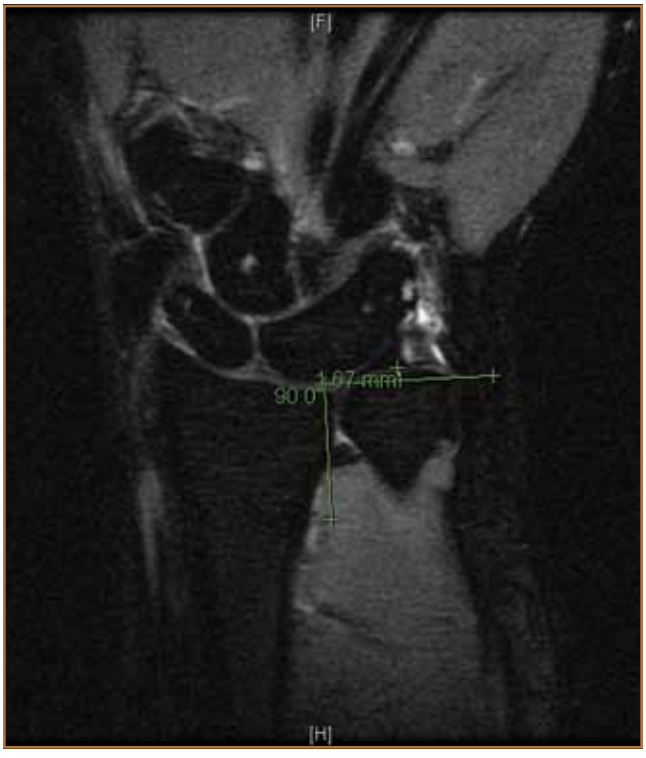

Figure 3. UV determination on gradient-echo MRI using project-a-line technique measuring cartilage to cartilage.

sitioning for MRI, without gradient-echo or short tau inversion recovery (STIR) sequence, without radiographs, without adequate studies, or with only a clench-fist radiographic view were excluded. Demographic data were recorded.

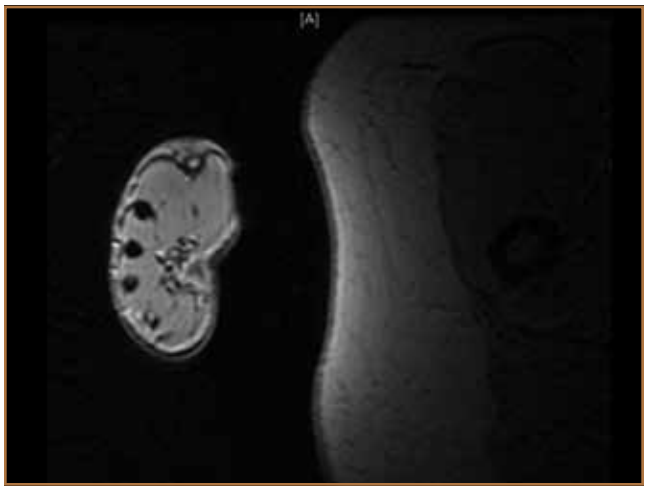

Figure 4. Scout MRI shows arm in neutral position at patient's side.

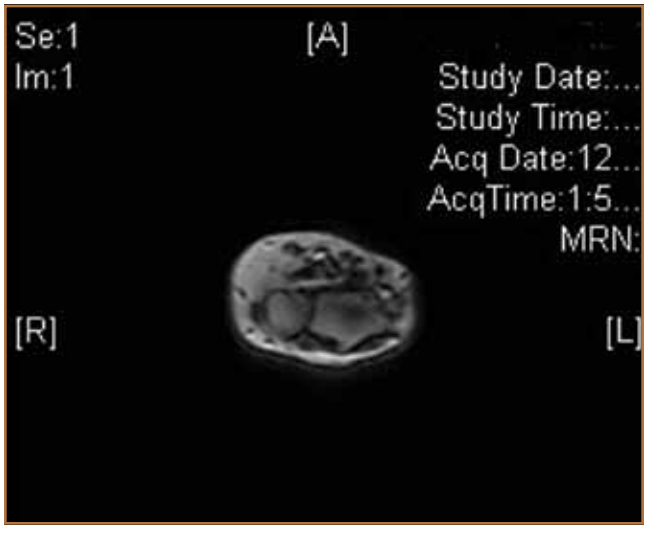

Figure 5. Scout MRI shows arm in over-the-head, Superman position.

Technique

Wrist and hand radiographs were taken according to a department imaging protocol in place: elbow flexed at 90°, shoulder abducted at 90°. UV was measured using the project-a-line technique, which has been shown to be reliable[9] and been used in current research[14] (**Figure 1**). Although other methods for determining UV are reliable,[15] project-a-line was the simplest to reproduce using our radiology viewing software. UV was measured at the highest ulnar height on the coronal T_1-weighted and cartilage-sensitive MRI sequences adopting the project-a-line method[9] as if it were a routine radiograph (**Figures 2, 3**). If no gradient echo was included, a STIR sequence was substituted. During MRI, the hand was either at the patient's side (**Figure 4**) or in the over-the-head, Superman position (**Figure 5**).

Analysis

Descriptive statistics were used to compare these data. Related-samples Wilcoxon signed rank tests were used to compare differences in mean UV as determined by MRI sequences and radiographs. Mann-Whitney U tests were used to determine significant differences between position and MRI sequences. To achieve a power of 80% given an α of 0.05 to detect a mean difference of 0.3 mm, we estimated we needed a minimum of 44 patients in each position group.[16] Analysis was performed with commercially available software.[17]

Results

MR images of 163 wrists (158 patients) were reviewed. Sixty-four wrists were excluded (per the criteria mentioned earlier), yielding 99 wrists (96 patients) with both MRIs and radiographs satisfactory for analysis. Mean (SD) age for the entire cohort was 42.2 (15.5) years.

Mean (SD) UV was −0.16 (2.43) mm on radiographs, −0.62 (2.41) mm on T_1-weighted (bone-to-bone) MRI, and −0.50 (2.38) mm on gradient-echo or STIR (cartilage-to-cartilage) MRI. Significant differences were found between radiographs and MRI as well as MRI sequences. Mean UV was significantly higher on radiographs versus T_1-weighted MRI (mean difference, −0.46 mm; $P < .001$), radiographs versus cartilage-sensitive MRI (mean difference, −0.34 mm; $P = .01$), and gradient-echo MRI versus T_1-weighted MRI (mean difference, −0.12 mm; $P = .027$) (**Figure 6**).

Hand position during MRI was not a statistically significant factor in determining UV. Sixty-four wrists were imaged at the patient's side, and 35 in the over-the-head, Superman position. Mean (SD) T_1-weighted UV was −0.40 (1.96) mm with the arm in the neutral position at the patient's side and −1.01 (3.06) mm with the arm in the over-the-head, Superman position ($P = .41$). Mean (SD) cartilage-to-cartilage UV was −0.36 (1.91) mm with the arm neutral at the patient's side and −0.64 (3.10) mm with the arm in the over-the-head, Superman position ($P = .78$) (**Figure 7**).

Discussion

UV changes according to which modality and which sequences are used to assess it. Radiographs may tend to underestimate the magnitude of negative UV. Conversely, compared with gradient-echo or STIR sequences, T_1-weighted MRI may overestimate the magnitude of clinically meaningful UV. Interestingly, arm position in MRI did not significantly affect UV in this cohort, though mean UV tended to be higher with the arm in the over-the-head, Superman position than in the neutral position at the patient's side. This is somewhat in contrast to the finding, in studies with plain radiographs, that apparent UV varies with position. Given that both elbow flexion and forearm rotation influence the anatomy at the wrist, combined flexion–rotation changes between the neutral and the over-the-head, Superman positions may neutralize each other with respect to UV and may not reflect more than normal left–right differences in measurement.[15,18,19] The large SDs on MRI may also be due in part to the fact that each patient is imaged sequentially and may move between scans. In addition, chemical shift artifact on MRI may influence UV measurement.[20] This artifact occurs at the cartilage–bone marrow interface, possibly leading to overestimation or underestimation of cartilage thickness. These conditions may explain variations between UV from one MRI sequence to the next and may limit the overall reliability of the determination of UV on

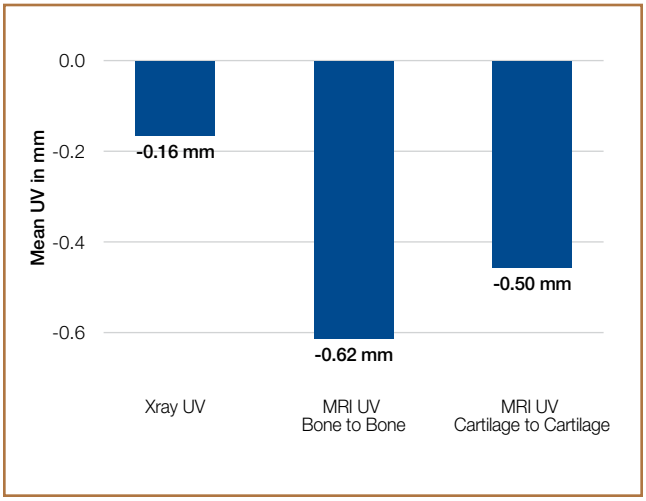

Figure 6. Mean UV displayed by imaging modality and sequence. Radiography and T_1-weighted MRI show bone to bone; gradient-echo or STIR MRI shows cartilage to cartilage.

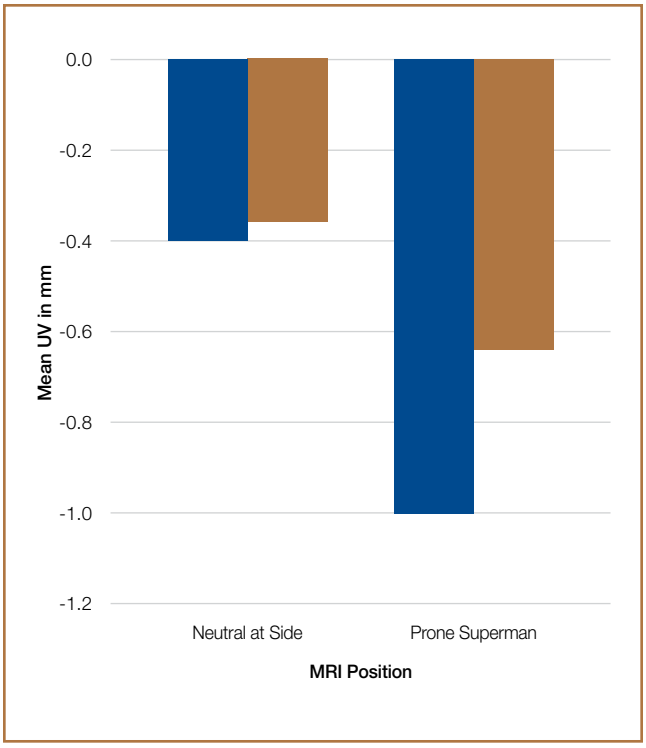

Figure 7. Mean differences in UV in MRI groups analyzed according to arm position in scanner.

MRI. Nevertheless, in today's high-tech world, in which many patients come to hand surgeon clinics with an MR image but no radiographs, it is important to be able to understand the impact of imaging modalities and imaging sequences on the determination of UV.

This article describes a method for measuring UV on different MRI sequences that can easily be executed on most radiology viewing programs. However, given our findings, it remains unclear which method for determining UV is the most clinically useful.

This study had several limitations. We did not meet the power requirements for the wrist-position analysis. Moreover, it is clear from viewing the radiographs that, despite having an imaging protocol in place, not all radiographs were obtained with the arm perfectly positioned, with the elbow at 90° of flexion and the shoulder abducted at 90°. However, this does represent an "intention-to-treat" method of analysis and increases our external validity to real-world clinical settings. Some of our statistically significant findings may not end up being clinically significant in future research. For example, the mean difference of 0.12 mm between MRI sequences is likely within the realm of measuring error, and it would be a challenge to prove a meaningful diagnostic or clinical endpoint. Further research is needed to validate the measurement of UV on MRI and to determine its clinical utility.

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