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Radiographic evaluation of partial articular radial head fractures: assessment of reliability

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Background: Historically, treatment of partial articular radial head fractures has hinged on radiographic assessment and application of the Mason classification. The inter- and intra-rater reliability of radiographic assessment and classification of radial head fractures may be lower than previously reported. We hypothesized that radiographic assessment leads to an underestimation of the number of fragments, percentage of articular surface involved, and displacement in millimeters.

Methods: We performed a retrospective review of all Mason II radial head fractures treated at our institution. Four independent observers performed radiographic assessment of the cohort. An independent observer performed these measurements on high-resolution computed tomography (CT) imaging, the reference standard. Radiographic assessments were then correlated with the CT findings using Pearson's correlation coefficient and Kappa statistic, where indicated.

Results: Fifty-nine Mason II radial head fractures were reviewed. These results were not impressive, with all comparisons showing a Kappa statistic less than 0.5 (ie, weak agreement). Intra-rater reliability was similar: displacement (measured by Pearson's correlation coefficient) was 0.58, percent articular involvement was 0.74, and the number of fragments (measured by the Kappa statistic) was 0.28. Fracture displacement was generally underestimated on radiographic measurements when compared to CT scan. Nearly half (45%) of all cases demonstrated inaccurate fragment number assessment when compared to the reference standard.

Conclusion: Radiographs show poor inter- and intra-observer reliability for determining radial head fracture morphology. Assessment of the number of fragments was particularly inaccurate. High-resolution CT should be considered for patients with Mason II radial head fractures, especially in cases of poorly visualized fracture characteristics or borderline amounts of displacement, in an effort to appropriately indicate patients for the variety of treatment options available today.

Mason type II radial head fractures are defined as those with a displaced, partial articular pattern. These are most commonly impaction and/or shear injuries of the most lateral aspect of the radial head with the forearm in supination.[18] There remains controversy as to which Mason type II fractures require surgical intervention. Classic recommendations involve measurement of the number of millimeters of articular depression and the percent of joint surface involvement.[4,18] For any classification system to reliably guide treatment, the imaging measurements on which that classification system is based must be accurate and reliable. Unfortunately, multiple studies have failed to demonstrate adequate inter-rater reliability of not only Mason's original system but also the newer modifications of the Hotchkiss and the Broberg and Morrey systems.[8,19,25] This most likely stems from the difficulty in determining subtle differences when imaging a round, 3-dimensional structure with plain radiographs.

Compared with plain radiographs, computed tomography (CT) may allow for greater accuracy in the measurement of fracture displacement and the percentage of the joint surface involved. Inter-rater reliability has been measured for both 2-dimensional (2D) and 3-dimensional (3D) CT imaging. In a study by Guitton and Ring, 2D CT imparted only fair (0.21-0.40) inter-rater reliability while 3D surface reconstructions were slightly better with a moderate (0.41-0.60) grade of inter-rater reliability.[10] This study used subjective data points, such as "comminution radial neck" (yes/no) and fracture fragments "too small to repair" (yes/no), in

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their assessment. In addition, a wide variety of fracture patterns were included.

To our knowledge, there are no data available comparing the reliability of radiographs to a reference standard (CT) through the use of objective, continuous measures of Mason II radial head fracture characteristics. Comminuted complete articular fractures (those in which no portion of the articular surface is in continuity with the diaphysis) have higher rates of ligamentous instability or other associated fractures and are most often treated surgically regardless of the particular fracture morphology. Mason II articular injuries, however, are much less likely to have significant concomitant fractures or ligamentous instability; thus, the decision on whether or not to operate relies on a true understanding of the morphology of the fracture and its displacement. The first aim of this study is to test the intra-rater and inter-rater reliability of plain radiographs for characterizing fracture displacement, percentage of articular surface involvement, and number of fracture fragments. The second aim is to compare these data against measurements on high-resolution CT scans (0.5 mm cuts). We hypothesize that radiographic assessment of Mason II articular radial head fractures is unreliable and underestimates the severity of the fracture morphology when compared to advanced imaging.

Materials and methods

After obtaining institutional review board approval, the billing records for 2 fellowship-trained upper extremity surgeons from January 1, 2006 through January 1, 2017 were reviewed. Cases of closed radial head fractures were identified using International Classification of Diseases 9 and 10 codes. Inclusion criteria included Mason type II radial head fractures, patient age of at least 18 years, and having obtained initial diagnostic radiographs and CT scans. Exclusion criteria included nonarticular fractures of the radial neck, complete articular fractures (Mason type III), and prior radial head fracture in the same extremity. Of the 1083 patients identified with a radial head fracture, 58 patients met all criteria. One patient had bilateral fractures which were counted separately for a total of 59 radial head fractures included for the study.

Baseline characteristics including age, sex, and presence of an associated coronoid fracture or capitellum fracture were tabulated. Initial injury radiographs including an anterior-posterior, oblique elbow, and lateral view were obtained in all cases. Two senior level residents (1 postgraduate year 4 and 1 postgraduate year 5) were recruited to independently review all 59 sets of radiographs. This was meant to mimic the experience level of a general orthopedic surgeon who has not undergone specialization for treatment of elbow conditions. Likewise, 2 experienced, fellowship-trained upper extremity surgeons with >15 years in practice, reviewed the images independently. Using our standard picture archiving and communication system viewer, the following measurements were performed by each reviewer: fracture displacement in millimeters, percent articular surface involvement (groupings included 0%-24%, 25%-49%, 50%-74%, and 75%-100%), and the number of independent fracture fragments. The portion of the radial head that was still attached to the diaphysis was counted as 1 fragment. Two weeks later, the database was redistributed to each independent reviewer and measurements were made a second time to assess intra-rater reliability.

All patients had CT imaging using 0.5 mm contiguous cuts. These images were reviewed for each case by a fifth independent observer (not involved in the measurements of the radiographs), a hand surgery orthopedic fellow in the last month of training. The fellow characterized fracture displacement, percent of articular surface involvement, and number of fragments based purely on 2-dimensional CT. The number of fragments was counted on the raw CT data using a combination of the axial, sagittal, and coronal reconstruction images to confirm the correct number for each case. Non-displaced fracture lines were not counted as separate fragments. Next, the radial head diameter was measured using the viewer's software. This was used as a reference standard for the remaining measurements.

Fracture displacement was calculated to the nearest tenth of a millimeter using the picture archiving and communication system software (NextGen PACS System, NextGen Healthcare, Atlanta, GA) (Fig. 1). The maximal displacement in any plane was taken as the degree of displacement (ie, if the axial image showed 2 mm of fracture displacement but the sagittal images revealed a split with 4 mm displacement, then 4 mm was used). This measurement was used as the reference standard for radiographic comparison of displacement.

The percent articular surface involvement was measured in SketchandCalc (www.sketchandcalc.com),[7] a computer software for measuring irregular shapes. The perimeter of each individual fracture fragment was traced on the most representative axial image (Figs. 2 and 3). The surface area of all fracture fragments was then measured and summated in square millimeters (mm^2). This measurement was then taken as the numerator while the total radial head articular surface area was used as the denominator. This equation produced a quotient representing the percentage of articular surface area involvement to the nearest tenth of a percent. These measurements, which were based on our high-resolution CT

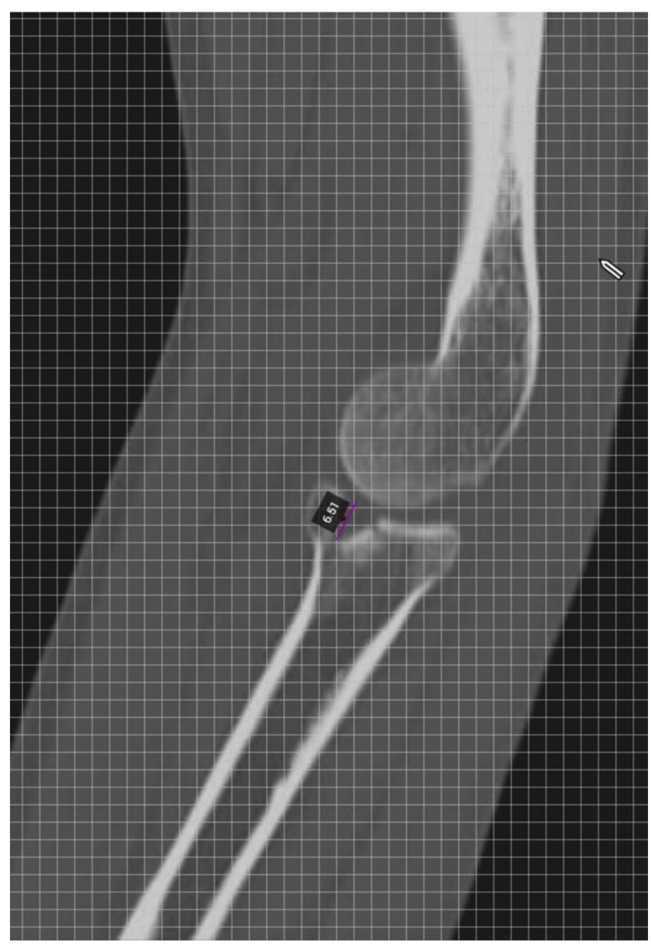

Figure 1 The fracture displacement was measured using the SketchandCalc application. The largest degree of displacement on any CT slice was taken as the displacement. Measurements were rounded to the nearest tenth of a millimeter. Thus, the measurement in this image was rounded to 6.5 mm. *CT*, computed tomography.

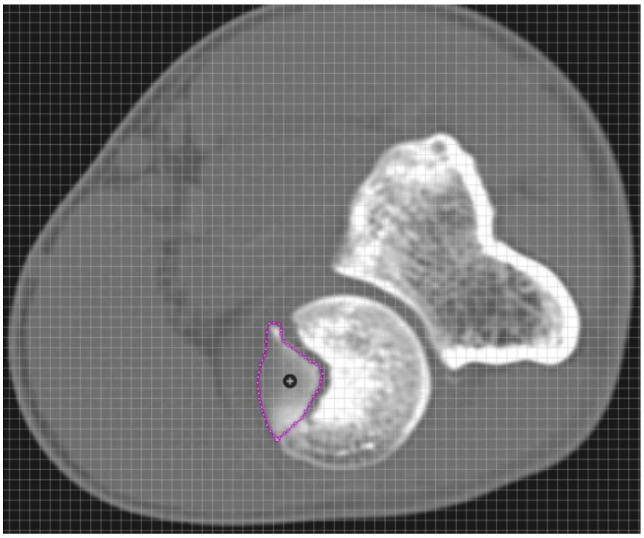

Figure 2 The surface area was measured for each comminuted fracture fragment by tracing the perimeter of the fragment on the SketchandCalc application. The total surface area of the fragments was measured using the program's functions and summed manually. All measurements were rounded to the nearest tenth of a square millimeter.

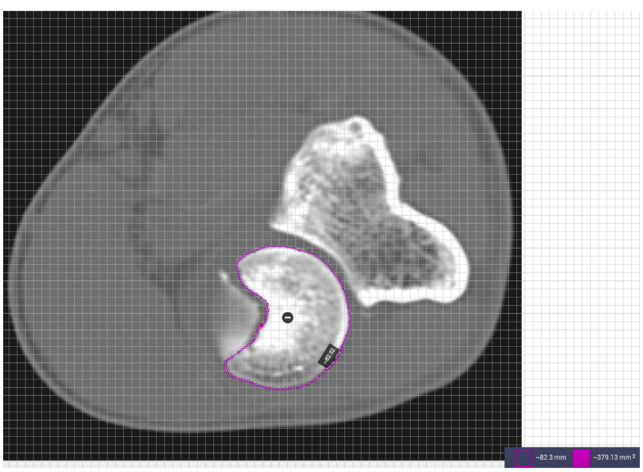

Figure 3 The surface area of the intact portion of the articular surface was also measured. This allowed for the entire surface area to be measured for the final calculation, by summing the surface area of the fracture fragments along with this final measurement. All measurements were rounded to the nearest tenth of a square millimeter.

imaging data, were used as the reference standard for radiographic comparison of head involvement.

Stata version 13.1 (StataCorp LLP, College Station, TX, USA) was used for the analysis. The level of significance was set at $P < .05$. The first set of analyses involved only the plain film images: Pearson's correlation coefficient was used to characterize the inter- and intra-rater reliability of fracture displacement and percent articular surface involvement. Similarly, the Kappa statistic was used to characterize inter- and intra-rater agreement for the number of fragments.

The second set of analyses compared the plain film and CT findings. Absolute differences between x-ray and CT were calculated for fragment displacement, percent articular surface involvement, and number of fragments. For displacement, each comparison between x-ray measurement and CT measurement was categorized as x-ray estimate < CT finding by 1 mm or more, x-ray estimate within 1 mm of CT finding, or x-ray estimate > CT finding by 1 mm or more. The same was repeated for a 2-mm threshold. For surface involvement, each comparison between x-ray measurement and CT measurement was categorized as x-ray estimate < CT finding by 10% or more, x-ray estimate within 10% of CT finding, or x-ray estimate > CT finding by 10% or more. The same was repeated for a 20% threshold. For the number of fragments, each comparison between x-ray measurement and CT measurement was categorized as x-ray estimate < CT finding, x-ray estimate same as CT finding, or x-ray estimate > CT finding.

For the third set of analyses, x-ray findings were tested for correlation with CT findings using Pearson's correlation coefficient (for displacement and percent articular involvement) or Kappa statistic (for number of fragments). Kappa statistics are a measure of agreement between 2 raters. According to Cohen's original description of the test in 1960, a score of 0.4-0.6 was deemed “moderate” agreement; however, it is now customary to deem a score below 0.6 to be a weak agreement for healthcare-related studies.[8]

The unit of analysis was each measurement (rather than each patient), such that each rater's assessment was directly compared to the CT finding (thus 4 comparisons were made for each patient). This analysis was repeated several times on different subsets of measurements based on injury film type (imported vs. taken at home institution), coronoid involvement (involving coronoid fracture vs. not involving coronoid fracture), distal humerus involvement (involving a distal humerus fracture vs. not involving a distal humerus fracture), and rater (attending vs. resident).

Results

Baseline characteristics were tabulated and are displayed in Table I. Inter-rater reliability of fracture displacement on radiographic analysis was calculated for all possible combinations of raters (Table II). In all but one case, inter-rater reliability was moderate (range, 0.3-0.7) while one comparison showed a strong correlation (range, 0.7-1). For percent articular surface involvement, the inter-rater reliability was less impressive (Table III). Two of the comparisons showed weak inter-rater reliability (range, 0-0.3). The remaining comparisons were moderate. Kappa statistic and percent agreement were calculated for inter-rater reliability of the number of independent fracture fragments (Table IV). These

Table I
Baseline characteristics.

	Summary statistic
Age (mean ± standard deviation)	46.4 ± 12.1
Sex (n, %)	
Male	29 (49.2)
Female	30 (50.9)
Associated coronoid fracture (n, %)	
No	50 (84.8)
Yes	9 (15.3)
Associated capitellum fracture (n, %)	
No	54 (91.5)
Yes	5 (8.5)

Table II
Pearson's correlation coefficient for inter-rater reliability of displacement.

	Rater 1	Rater 2	Rater 3	Rater 4
Rater 1	-	-	-	-
Rater 2	0.5410	-	-	-
Rater 3	0.5527	0.5879	-	-
Rater 4	0.3978	0.8069	0.5692	-

Table III
Pearson's correlation coefficient for inter-rater reliability of percent articular surface involvement.

	Rater 1	Rater 2	Rater 3	Rater 4
Rater 1	-	-	-	-
Rater 2	0.2618	-	-	-
Rater 3	0.5101	0.4951	-	-
Rater 4	0.5424	0.2468	0.4553	-

Table IV
Kappa statistic (and percent agreement) for inter-rater reliability of number of fragments.

	Rater 1	Rater 2	Rater 3	Rater 4
Rater 1	-	-	-	-
Rater 2	0.3598 (67.8%)	-	-	-
Rater 3	0.4653 (74.6%)	0.4639 (72.9%)	-	-
Rater 4	0.225 (69.5%)	0.216 (61.0%)	0.1074 (61.0%)	-

results were not impressive, with all comparisons showing a Kappa statistic less than 0.5.

'Intra-rater reliability was calculated using the pooled data for all 8 measurements. Results showed moderate agreement for displacement, strong agreement for percent of articular involvement, and poor agreement for the number of fragments (Table V).

The results comparing the interpretations of the radiographs to CT scan as the reference standard can be reviewed in Table VI. Fracture displacement was generally underestimated rather than overestimated on radiographic measurements. When a 1 mm disagreement threshold was used, radiographic measurements were accurate 71.8% of the time, while they underestimated the displacement 16.5% of the time. With a less stringent disagreement threshold of 2 mm, agreement improved to 91.7%. There was a preponderance for underestimating (7.2%) as opposed to overestimating (1.1%) the displacement compared to the CT scan. Interestingly, percent articular surface involvement was overestimated by 10% or more in a quarter of all cases. The number of fragments was highly variable on radiographic assessment with nearly half (45%) of all cases being inaccurate when compared to the reference standard. Of those inaccurate cases, the examiner was twice as likely to underestimate the number of fragments than to overestimate the number of fragments (Fig. 4).

Table V
Intra-rater agreement.

	Intra-rater agreement
Displacement (Pearson's correlation coefficient)	0.5787
Percent articular involvement (Pearson's correlation coefficient)	0.7402
Number of fragments (Kappa [% agreement])	0.2787 (67.1%)

Table VI
Agreement between CT and x-ray findings—absolute differences.

	Percent
Displacement within 1 mm	
X-ray estimate < CT finding by 1 mm or more	16.5
X-ray estimate within 1 mm of CT finding	71.8
X-ray estimate > CT finding by 1 mm or more	11.7
Displacement within 2 mm	
X-ray estimate < CT finding by 2 mm or more	7.2
X-ray estimate within 2 mm of CT finding	91.7
X-ray estimate > CT finding by 2 mm or more	1.1
Percent surface involvement within 10%	
X-ray estimate < CT finding by 10% or more	12.5
X-ray estimate within 10% of CT finding	61.4
X-ray estimate > CT finding by 10% or more	26.1
Percent surface involvement within 20%	
X-ray estimate < CT finding by 20% or more	4.9
X-ray estimate within 20% of CT finding	89.8
X-ray estimate > CT finding by 20% or more	5.3
Number of fragments	
X-ray estimate < CT finding	29.7
X-ray estimate same as CT finding	55.7
X-ray estimate > CT finding	14.6

CT, computed tomography.

Radiographic assessment appears to be highly sensitive to detect those injuries with large surface area involvement and significant displacement (Table VII), but with low specificity. Comminution, however, was detected poorly by plain radiographic assessment, with a sensitivity of just 41% (Table VII).

Correlations for the entire dataset were compared between the radiographic measures of displacement, percent articular involvement, and number of fracture fragments. Subgroup calculations for various baseline characteristics were performed (Table VIII). Notably, displacement and percent articular surface involvement demonstrated only moderate agreement between x-ray and CT ($r = 0.47$ and 0.32, respectively). There was no agreement for the number of fracture fragments ($k = 0.13$).

There was a significant improvement in agreement for radiographs obtained in the clinic ($r = 0.61$) vs. imported films ($r = 0.23$). When a coronoid fracture was present, displacement showed no agreement ($r = -0.02$), and percent articular involvement showed minimal agreement ($r = 0.23$). A concomitant distal humerus fracture led to diminished agreement for fracture displacement ($r = 0.07$) and number of fragments ($k = 0.00$). Thus, concomitant humerus or ulna fracture appears to make interpreting the radiographs more challenging.

Attending raters and resident raters demonstrated similarly poor levels of agreement between radiographs and CT scan for each of the 3 variables: fracture displacement, percent articular involvement, and the number of fracture fragments. Both groups had difficulty identifying the correct number of fracture fragments, with poor agreement demonstrated against the CT scan in both groups (Table VIII).

Discussion

The Mason classification has its shortcomings. Specifically, it cannot reliably predict the amount of comminution or the complexity of the fracture. In addition, it demonstrates only fair-to-moderate inter-observer and intra-observer reliability using plain radiographs.[12] While improvements to the classification system have been offered,[4,11,25] these modifications have not translated into agreement over clinical decision-making.[14]

Surgical indications for Mason II articular radial head fractures remain controversial. Early case series by Akesson, Lindenhovious, and Miller have each suggested that Mason type II fractures (Orthopaedic Trauma Association [OTA] 2R1B) should be treated nonoperatively, despite variable clinical outcomes.[1,17,20] However, the surgical cases observed in these studies were performed in the 1970s and 1980s, with outdated techniques and implants.[2] Thus, the findings of these studies may not be reliable when considering modern techniques and implant options.

A number of other authors have argued in favor of surgical intervention in Mason II fractures (OTA 2R1B) in order to achieve optimal articular reduction.[2,9,15,16,22] Malunion in these injuries can lead to painful loss of function.[3,23,24] Miller et al, in a cadaveric model, demonstrated significant lack of full forearm rotation with some Mason type II fractures (OTA 2R1B). In their study, a 3 mm step-off led

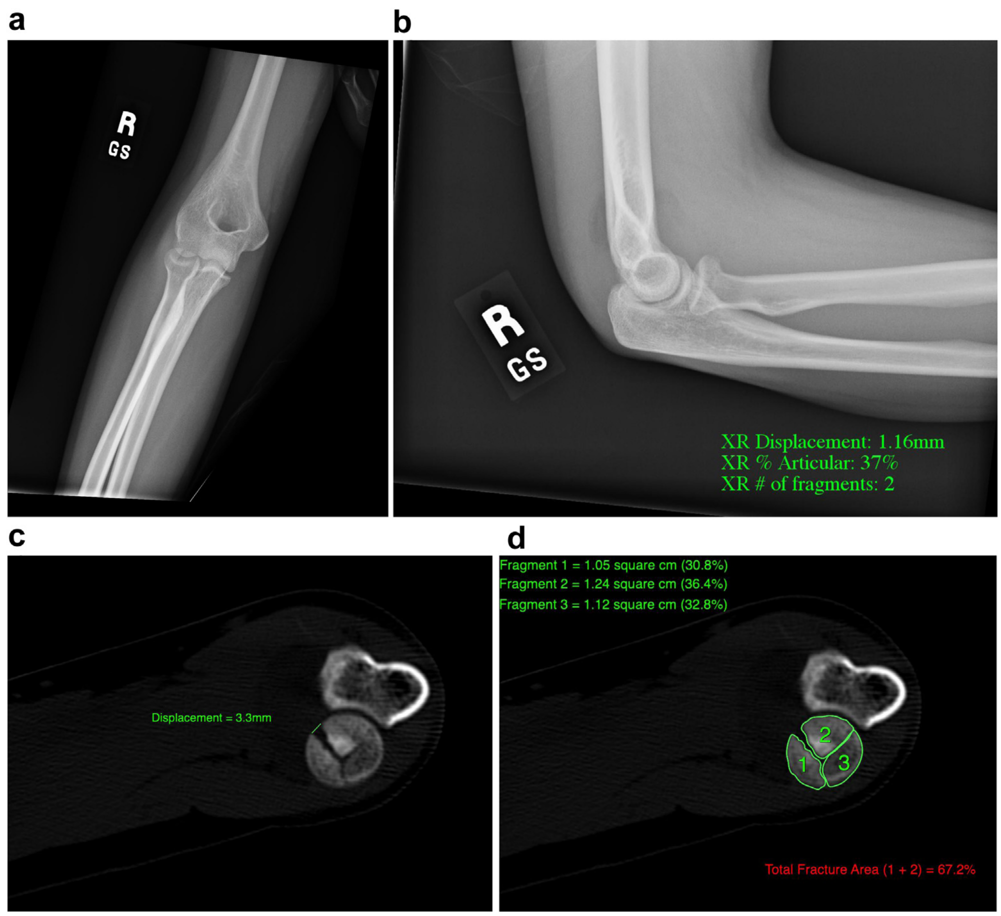

Figure 4 (**a**-**d**) A case example of a 31-year-old female who suffered an isolated Mason II radial head fracture. Average measurements among all reviewers are visible in (**b**). Reference measurements using the reference standard CT imaging are listed in (**c**) and (**d**), alongside their representative measurement depictions. For all 3 parameters, radiographic assessment considerably underestimated the severity of the fracture. *CT*, computed tomography, *R*, right, *XR*, x-ray.

Table VII
Test statistics for x-ray predicting CT.

	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Displacement >2 mm	90	36	72	67
Percent surface involvement > 40%	81	48	68	65
Number of fragments > 3	41.4	71.7	58.5	55.8

CT, computed tomography; *PPV*, positive predictive value; *NPV*, negative predictive value.

Table VIII
Agreement between x-ray and CT findings—correlation coefficients and kappa statistics.

	All x-rays	Only non-imported x-rays	Only imported x-rays	Only without coronoid fracture	Only with coronoid fracture	Only without distal humerus fracture	Only with distal humerus fracture	Only attending x-ray estimates	Only resident x-ray estimates
Displacement (Pearson's correlation coefficient)	0.4653*	0.6132*	0.2252*	0.6003*	−0.0189*	0.4755*	0.0731	0.4963*	0.4387*
Percent articular involvement (Pearson's correlation coefficient)	0.3228*	0.2993*	0.3478*	0.3403*	0.2257	0.3039*	0.5740*	0.3260*	0.3477*
Number of fragments (Kappa [% agreement])	0.1338* (55.7%)	0.1692* (56.4%)	0.0698 (54.6%)	0.1613* (56.8%)	−0.0189 (50.0%)	0.1232* (56.5%)	0.0000 (47.5%)	0.1258* (55.1%)	0.1418* (56.4%)

CT, computed tomography.
* Denotes statistical significance of $P < .05$.

to a significant increase in the range of motion deficit.[21] Currently, 2 mm of depression or step-off is the generally accepted cutoff for operative intervention, due to concerns of stiffness and elbow degenerative disease over time with more severe displacement.[13]

In an effort to consolidate the available data, Kaas et al performed a systematic review on the treatment of Mason type II fractures (OTA 2R1B) in 2015. They found a total of 9 level IV retrospective case series related to the topic. In an effort to focus the debate on stable, isolated Mason II radial head fractures, the authors chose to exclude any data involving radial head fractures as part of a more complex injury such as fracture-dislocations. Despite the exclusion of these "more severe" injury patterns, they were unable to determine the superiority of one treatment over the other.[14]

With increased access to advanced imaging, the use of more precise CT imaging to guide treatment of these difficult fracture patterns seems promising. In 2011, Guitton and Ring[10] assessed the inter-rater reliability of 2D CT and 3D CT for evaluation of radial head fractures of all different types. This assessment was performed via observer assessment of 7 subjective fracture characteristics. Afterward, each observer was asked to categorize the fracture according to the Broberg and Morrey modification of the Mason classification. They found that 3D CT reconstructions showed moderate agreement and 2D CT showed only fair agreement among observers. While they had an impressive 85 surgeons participate in the study, the results and conclusions had some limitations. Since all questions but their primary research question were underpowered, the authors state that their results "should be interpreted with caution." Another limitation of this study was that only subjective, categorical data were used for statistical comparison. Lastly, there was no reference standard for comparison of true fracture size or displacement. Nonetheless, they concluded that radial head fracture classification is more reliable among observers with the use of advanced CT imaging, when compared with radiographic assessment alone.[10]

We found radiographs to show low to moderate agreement for fracture displacement ($r = 0.46$), poor agreement for articular surface involvement ($r = 0.32$), and no agreement for the number of fracture fragments ($k = 0.13$) when compared to CT scan (Table VII). These findings compare favorably to similar studies using x-ray and CT scan for other intra-articular fractures including distal radius[6] and distal humerus.[5]

Our findings also corroborate previous reports of the intra-rater reliability of radial head fractures assessed with plain radiographs. Among observers, there was fair to moderate agreement with regard to fracture displacement and the number of fracture fragments (Table V). However, when compared to high-resolution CT imaging, our reference standard, these numbers become less impressive. When absolute differences between radiographic assessment and CT assessment are compared, radiographic assessment of fracture displacement was inaccurate by 1 mm or more in almost 30% of cases. This comparison improved to 8% inaccuracy when a cutoff of 2 mm or more was analyzed (Table VI). As shown in the results, when inaccurate the tendency was for radiographs to underestimate the displacement. One way to apply these data in a clinically relevant way is that for a fracture that appears non-displaced or 1 mm displaced, using >2 mm as a potential indication for surgery, a CT scan is unlikely (7%) to demonstrate enough of an increase in displacement to change management. However, in cases which appear "borderline," with concern for 2 mm of displacement, a CT scan may very well show a greater degree of true displacement and lead the surgeon to consider surgical intervention.

When comparing radiographs and CT scans, the number of fracture fragments was even less accurate than for fracture displacement, with roughly 45% of cases being inconsistent with the actual CT findings (Table VI). Among the cases of inaccurate fracture fragment tabulation, the number of fragments was underestimated by a 2:1 ratio. One way to apply these data clinically may be that while the presence of a greater number of fracture fragments does not represent an absolute indication for surgery, it is important information in guiding treatment, especially when surgery is elected. For fractures with multiple articular fragments CT scans can be an important part in precisely planning access to the fragments, as well as optimizing the starting points and trajectories of the screw fixation commonly applied for Mason II fractures (OTA 2R1B). A lateral approach typically only provides access to a limited portion of the circumference of the radial head, making optimized preoperative planning essential.

The percent involvement of the articular surface showed moderate to strong inter- and intra-rater reliability on radiographic assessment (Table V). However, this becomes less impressive when compared to the reference CT imaging, as roughly 40% of cases were inaccurate by 10% or more (Table VI). Given that prior studies have demonstrated 30%-40% articular involvement as a relative indication for surgical fixation,[4] the inaccuracy demonstrated in this study is certainly worrisome. As the surface area of the free fracture fragment increases, this portends a higher risk of edge loading and possible early radiocapitellar arthritis. Based on our results, we would thus recommend that a CT be considered in any borderline case.

When baseline characteristics of fracture pattern and type of observer were parsed out, there were a few interesting findings (Table II). In cases where injury films came from an outside facility, the reliability to assess percent articular involvement and the number of fragments did not change. However, the inter-rater reliability to assess displacement dropped from moderate to fair. This highlights the importance of obtaining high-quality orthogonal images. Despite a patient's inability to fully extend the elbow in the acute setting, anteroposterior images should be centered at the elbow and be taken perpendicular to the forearm axis whenever possible.

When the radial head fractures in our study were associated with a distal humerus or coronoid injury, there was a significant decline in the reliability of radiographic assessment. This may be due to overlap of fractures on the plain films making interpretation difficult. While CT evaluation is typical for large coronoid fractures or intra-articular distal humerus fractures, our study suggests that a CT scan may be beneficial for even small coronoid fractures that could obscure radiographic evaluation of an otherwise isolated radial head fracture.

Lastly, there was no difference in the reliability of senior residents as compared to fellowship-trained hand surgeons with more than 30 years of combined practice for all the measured parameters. This suggests that the ability to judge a given fracture does not improve with experience, but rather the limitations of using plain radiographs to evaluate and judge Mason II fractures of the radial head persist.

There are several limitations in this study. The retrospective nature of the study design places our findings at risk for selection and other biases. However, we reviewed every radial head fracture in our practice from 2006 until 2017. All Mason II radial head fractures that met the inclusion/exclusion criteria were studied. Given that we were not measuring the effects of a treatment on clinical outcomes, we believe that selection bias played a minimal role in our findings. Another shortcoming is that the quality of radiographs was limited to what was obtained at the time of injury. In those cases where inadequate films were obtained by the local emergency room, a new set of films from the first office visit were used for this study. Finally, radiographs and CT scans were not standardized against a magnification marker. While this may have had some effect on the displacement measurements, it should not have changed the judgment of percent articular involvement or number of fracture fragments. Our hope is that this limitation would have minimally affected our data.

Conclusions

This study demonstrated that radiographic measurements of fracture characteristics of Mason II radial head fractures (OTA 2R1B) are associated with suboptimal reliability, and they often lead to an underestimation of the severity of the fracture pattern when compared to CT imaging. Advanced CT imaging of the elbow should be considered in any borderline case in which the aforementioned measurements will be relied upon for the final treatment decisions. Management of partial articular radial head fractures is controversial, and treatment recommendations should be handled on a case-by-case basis.

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