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Original Research

Preoperative Computed Tomography Scan in Distal Radius Fractures and the Effect on Preoperative Planning

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A R T I C L E I N F O

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Purpose: It is unclear whether computed tomography (CT) scans alter the surgical plan when ordered before surgery for fixation of intra-articular distal radius fractures (DRFs). The purpose of this study was to determine whether a preoperative CT scan alters the planned approach (PA) or planned fixation strategy (PFS) for open reduction internal fixation of intra-articular DRFs.
Methods: Radiology records were retrospectively reviewed by one trauma surgeon and two hand surgeons for 33 intra-articular DRFs that met the inclusion criteria and previously underwent open reduction internal fixation. Surgeons were initially provided only preoperative radiographs; they were asked for their PA and PFS. Three months later, each surgeon was provided with the same preoperative radiographs as well as a CT scan. They were asked for their PA and PFS and to grade the usefulness of CT for each fracture.
Results: The overall probability of having the same PA and PFS between the two presentations was 70.6% and 70.9%, respectively. There was a significant difference in opinion on the usefulness of the CT scan among the surgeons ($P < .001$).
Conclusions: This study suggests that ordering a CT scan for preoperative planning of open reduction internal fixation for an intra-articular DRF does not affect the approach or fixation strategy in the majority of cases, regardless of how useful a CT scan was determined to be by the surgeon.
Type of study/level of evidence: Therapeutic IV.

Distal radius fractures (DRFs) are the most common fracture of the upper extremity, occurring at an incidence of 600,000 per year in the United States.[1] Some intra-articular DRFs can be very challenging to manage, particularly given the increased risk of posttraumatic arthritis with articular incongruities.[2] According to the 2020 American Academy of Orthopaedic Surgeons Clinical Practice Guidelines, moderate evidence supports operative treatment of DRFs with radial shortening >3 mm, dorsal tilt >10°, or intra-articular displacement or step off >2 mm in nongeriatric patients aged <65 years.[3] Although radiographic parameters for surgical management are fairly well established, there is still debate regarding the adequacy of radiographs alone for surgical planning prior to fixation of intra-articular DRFs.[4,5] Previous studies have shown poor interobserver and intraobserver reliability of classification of intra-articular DRFs with radiographs alone.[6] Owing to the ease of obtaining computed tomography (CT) scans, surgeons are opting to get CT scans for an increasing number of intra-articular DRFs.[7,8] Computed tomography scans improve visualization of the articular surface, and one prior study found that surgeons are more likely to treat a DRF operatively if a CT scan is obtained.[7,8] The question remains as to whether obtaining a CT scan is necessary before surgery from a cost perspective.

Declaration of interests: No benefits in any form have been received or will be received related directly to this article.

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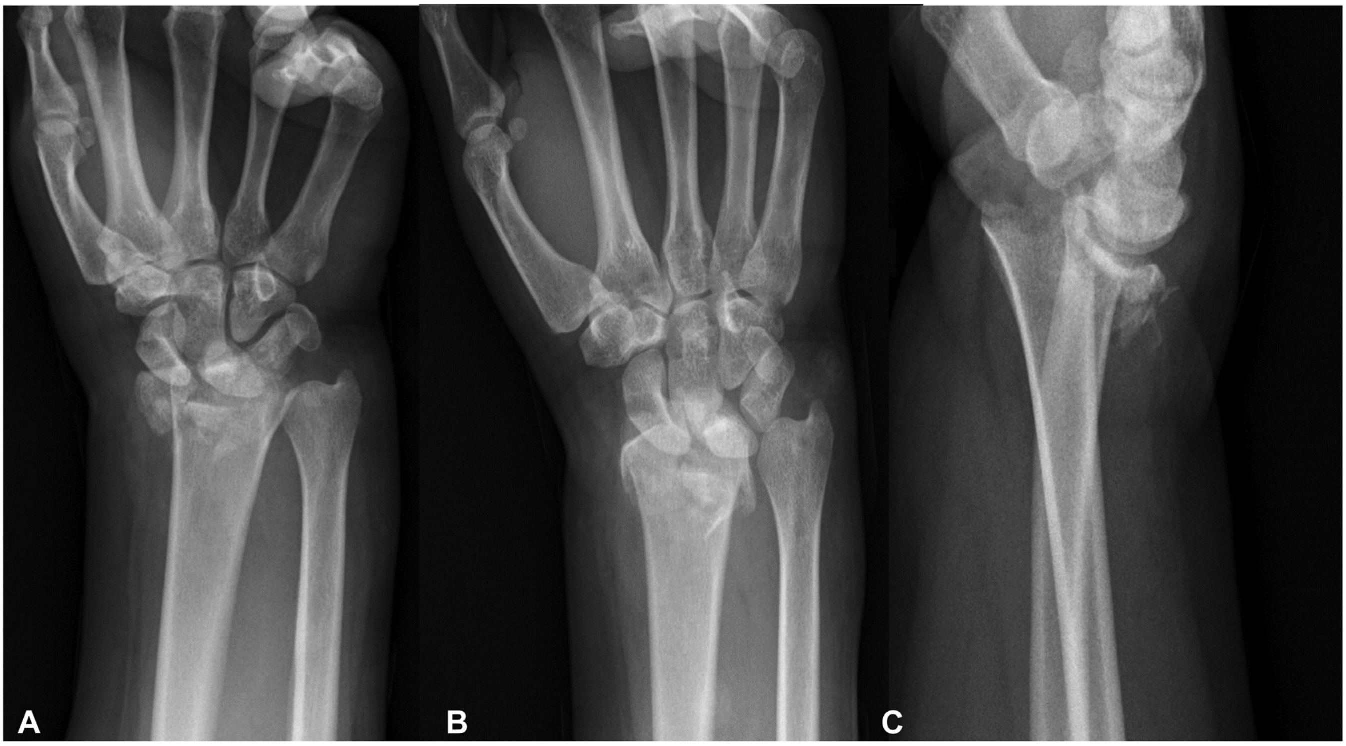

Figure 1. Representative **A** posteroanterior, **B** oblique, and **C** lateral radiographs of an intra-articular DRF.

One reason why there may not be a consensus on how helpful CT scans are is the wide array of surgical approaches and fixation options that exist for DRFs.[5,9,10] Previous literature has not examined how surgeons' specific operative plans might be affected by viewing a CT scan. The purpose of this study was to determine whether obtaining a preoperative CT scan prior to fixation of an intra-articular DRF changes the surgeon's surgical treatment plan.

Materials and Methods

One trauma and two hand fellowship–trained orthopedic surgeons were independently presented the radiographs of intra-articular DRFs. Surgeons were first presented with deidentified prereduction and postreduction wrist radiographs (posteroanterior, oblique, and lateral views) and asked to provide their planned approach (PA) and planned fixation strategy (PFS) (Fig. 1). Approach options included closed treatment, volar, dorsal, combined (volar + dorsal), and other; fixation strategy options included cast, external fixator, bridge plate, pinning, volar plate, dorsal plate, fragment-specific plating, a combination of these, and other.

Three months after this, the same three surgeons were provided the same DRF radiographs now with the addition of axial, coronal, and sagittal CT scan imaging of the wrist as well as 3-dimensional (3D) reconstruction images (Fig. 2). They were again asked to provide a PA and PFS. In addition, they were asked if the CT scan affected surgical decision making for each fracture; this was graded on a Likert scale (strongly disagree, somewhat disagree, neutral, somewhat agree, and strongly agree). It was believed that the 3-month interval between presentations was enough time to decrease the risk of the surgeons' recalling their previous responses and was appropriate based on previous similar literature with intervals ranging from 2 to 16 weeks.[11–13]

We included patients aged 18 years or older who presented between January 1, 2015, and April 5, 2020 at a level one trauma center with an intra-articular DRF treated with open reduction internal fixation. In addition, patients were eligible to be included if they had a preoperative three-view wrist radiograph (posteroanterior, lateral, and oblique views) and a preoperative CT scan (axial, sagittal, coronal, and 3D reconstruction images). Cases were excluded if the fracture was treated by one of the surgeons participating in this study, a CT scan was obtained for the primary purpose of evaluating a carpal bone fracture, a CT with contrast was obtained to evaluate for vascular injury in the setting of a gunshot wound, or surgical fixation was performed more than 6 weeks after injury as we considered this to be malunion surgery. Data on demographic and clinical characteristics, fracture characteristics, the final approach, and the final fixation strategy were collected from the patients' medical records.

Data were analyzed using SAS/STAT software version 9.4 (SAS Institute). Descriptive statistics were calculated for demographic, clinical, and disease characteristics. Univariable logistic regression was used to investigate the association between agreement and either presentation, fracture type, or surgeons. Patients were included in the model as a random effect. A P value of <.05 was considered statistically significant. The study was approved by the site's Institutional Review Board.

Results

A total of 33 intra-articular DRFs met the inclusion criteria for the study. Patients were predominantly women (69.7%) and of Caucasian race (65.6%). Mean age was 40.1 years. Mean body mass index was 27.4 kg/m^2 (Table). According to the Arbeitsgemeinschaft für Osteosynthesefragen classification, 72.7% of the fractures were type C (n = 1 for C1, n = 2 for C2, and n = 21 for C3) and 27.3% were either type A (n = 2 for A2) or type B (n = 5 for B2 and n = 2 for B3). The overall probability of having the same PA and PFS between the two presentations (radiograph vs radiograph + CT scan) was 70.6%

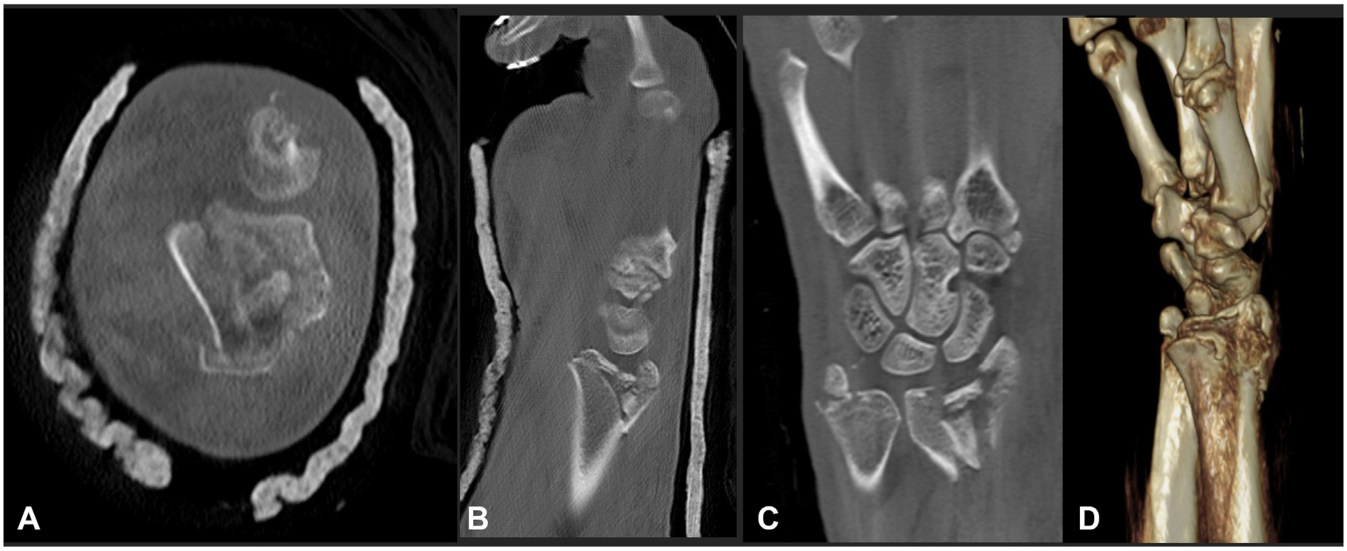

Figure 2. Representative **A** axial, **B** sagittal, **C** coronal, and **D** 3D reconstruction CT scan images of an intra-articular DRF.

Table
Patients' Demographic and Clinical Characteristics (n = 33).

Characteristic	Value
Age (y), mean (SD)	40.1 (13.9)
BMI (kg/m^2), mean (SD)	27.4 (9.7)
LOS (d), mean (SD)	9.9 (11.6)
Sex, n (%)	
Male	30.3 (10)
Female	69.7 (23)
Race, n (%)	
Black	28.1 (9)
Caucasian	65.6 (21)
Other	6.3 (2)
Insurance, n (%)	
Commercial	33.3 (11)
Medicare	9.1 (3)
Medicaid	24.2 (8)
Other	33.4 (11)
ISS, n (%)	
<10	39.4 (13)
10–14	36.4 (12)
>15	24.2 (8)
AO Fracture classification, n (%)	
2R3A2.3	6.1 (2)
2R3B2.2	9.1 (3)
2R3B2.3	6.1 (2)
2R3B3.1	6.1 (2)
2R3C1.1	3.0 (1)
2R3C2.1	3.0 (1)
2R3C2.3	3.0 (1)
2R3C3.1	6.1 (2)
2R3C3.2	45.5 (15)
2R3C3.3	12.1 (4)

AO, Arbeitsgemeinschaft für Osteosynthesefragen; BMI, body mass index; ISS, injury severity score; LOS, length of stay.

and 70.9%, respectively. There was no significant difference in agreement among surgeons for the PA and PFS before and after CT. Agreement was 69.4%, 69.4%, and 73.0% for the PA ($P = .94$) and 72.9%, 66.8%, and 73.0% for the PFS ($P = .82$) for surgeons A, B, and C, respectively. Although no differences were observed among the three surgeons in the effect of the CT scan on their decisions, surgeons had a different opinion on the CT scan's usefulness ($P < .001$, Fig. 3). Surgeon A strongly disagreed that the CT scan was helpful in the decision-making process in more than 50% of the cases.

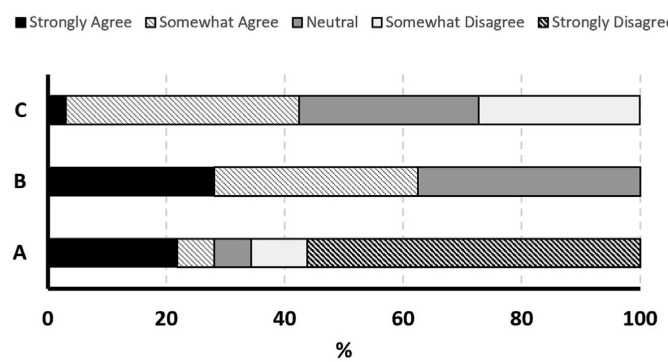

Figure 3. Surgeon (A, B, and C) opinions on CT scans being helpful in their surgical decision making.

Surgeon B chose either "somewhat disagree" or "strongly disagree" on the utility of CT scan for every case. Surgeon C chose varying answers on the utility of CT scan for each case.

Fracture classification did not significantly affect the decision-making process for the PA (56.7% for type A/B and 75.6% for type C, $P = .27$) or the PFS (77.9% for type A/B and 68.3% for type C, $P = .39$, Fig. 4).

Discussion

Owing to the increasing incidence of DRFs and the ease of obtaining CT scans, more surgeons are opting to obtain CT scans to better assess intra-articular DRFs prior to surgical intervention. However, the addition of CT scans adds further radiation exposure, costs, and potential delays in treatment. It is not known how often the CT scan changes the operative plan and the overall effect that CT scans have on surgeon decision making compared to radiographs alone. Most previous studies have focused on the effect a CT scan has on joint evaluation, fracture classification, and nonsurgical versus operative treatment.[11,13]

Our study suggests that the addition of CT scans does not affect the approach or fixation strategy for intra-articular DRFs in approximately two-thirds of cases. The majority of our cases were Arbeitsgemeinschaft für Osteosynthesefragen classification type C

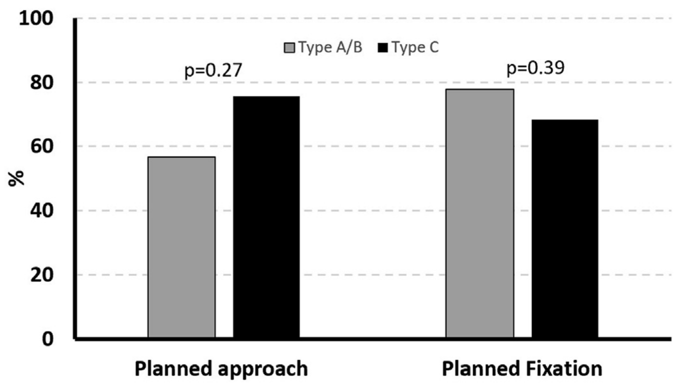

Figure 4. Overall agreement between presentations for the PA (gray) and PFS (black) by the Arbeitsgemeinschaft für Osteosynthesefragen classification.

fractures, but there was greater disagreement on the PA in type A/B fractures, although not statistically significant ($P = .27$). This may be due to the wide array of options for treating these fractures. For the PFS, surgeons were more likely to agree with themselves between presentations for type A/B fractures compared to type C fractures, but the results were also not statistically significant ($P = .39$). Interestingly, the surgeons had a wide array of opinions on the usefulness of the CT scan ($P < .001$).

A previous study by Harness et al[13] examined 30 intra-articular DRFs. Radiographs and CT scans were provided to four participants (one resident, two fellows, and one hand surgeon). They found that CT scans aided in identifying certain fractures, that the treatment plan changed 48% of the time when 3D images were added, and that closed treatment was selected less often when 3D images were added.[13] Comparatively, the present study included only attending-level reviewers, who are presumably more advanced in interpreting both radiographs and CT scans and in deciding on an operative plan than residents or fellows. Radiographs and CT scans were always provided together in the previous study, but they added in 3D reconstruction images as a separate presentation, whereas we provided radiographs separately from CT scans. We were unable to directly compare results in terms of how 3D reconstruction images affected the PA and PFS because we always provided them with the CT scan.

Katz et al[11] provided four hand surgeons with x-rays and CT scans of 15 intra-articular DRFs and had them select one of eight treatment options provided as well as take measurements. Similar to our study, one presentation provided only radiographs while the other provided both radiographs and CT scan images. Treatment options were selected from a list, although there were no 3D reconstruction images and the treatment options were different from those in our study. Computed tomography scans improved the evaluation of the articular surface, comminution, assessment of the distal radioulnar joint, and articular gapping. Overall, CT scans changed management in 27% to 53% of cases, with the largest effect being on closed surgical management, which was changed to open surgical management.[11] One reason why this study may have found CT scans to be more useful is that our study evaluated DRFs that had already undergone open reduction internal fixation, indicating that they met open operative criteria. In addition, that study did not compare specific surgical approaches.

By examining 51 DRFs with radiographs and CT scans with four observers, Kleinlugtenbelt et al[12] found that CT scans improved intraobserver agreement in therapeutically uncertain cases but actually decreased the agreement in therapeutically certain cases. Overall, the intraobserver agreement did not increase with the addition of a CT scan when certainty was not considered.[12] Compared to our study, two of the four observers in that study were trauma surgeons, no 3D reconstruction images were provided, and they did not assess specific treatment plans, only nonsurgical versus operative treatment. The addition of therapeutic certainty makes this study unique. Certainty was defined as how confident the surgeon was in their treatment plan and was graded on a scale of very uncertain, uncertain, somewhat uncertain, certain, or very certain. The very uncertain and uncertain groups were combined into one due to low numbers. In our study, all fractures were already appropriate for open reduction internal fixation, which may explain why CT scans were not as useful in determining management as expected.

Limitations of the present study include its retrospective nature and small sample size; however, our cohort of 33 fractures is comparable to similar studies on the topic with cohorts of 15, 30, and 51 patients.[11–13] No a priori power analysis was conducted as not many patients met all of the inclusion criteria. Although an increase in sample size would likely allow us to detect significant differences between fracture types, the primary objective was the agreement between presentations, which was high and numerically similar (≈70%) between the two; therefore, the main conclusions would have not been affected by increased power. In addition, we were only able to have three surgeons evaluate the images, whereas some other studies had four observers; however, all of our observers were hand or trauma fellowship–trained orthopedic surgeons. The radiographs and CT scans were not standardized or taken with specific instructions; therefore, slight differences in the images could have influenced how the fractures were seen. Another limitation is that the patient order was not changed between presentation one and presentation two, but given that a minimum of 3 months was used between case presentations, it is unlikely that the surgeons remembered what answers they selected. We did not take specific measurements for displacement to compare the radiographs and CT scans, but it has been established in the literature that CT scans are superior for evaluating the articular surface. In addition, we did not perform financial analysis on how the CT scan itself increased costs and, when the operative plan changed, whether there was a difference in cost.

Overall, this study shows that ordering a CT scan for preoperative planning after an intra-articular DRF does not affect the approach of fixation strategy in the majority of cases. Owing to the concern for both preventing posttraumatic arthritis and obtaining an understanding of the nature of the fracture prior to operative treatment, some surgeons may continue to elect to obtain CT scans of all intra-articular DRFs. However, we present evidence that even with varying opinions on the utility of CT scan for specific fractures by individual surgeons, there was no significant change to the operative plan with the addition of CT imaging. Future studies with larger sample sizes will be needed to determine the necessity of CT scans in these injuries, if the addition affects long-term outcomes, and how it may affect costs.

Acknowledgments

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