Quality of Mini C-Arm Imaging in Post-Reduction Evaluation of Distal Radius Fractures

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Disclosures:

• None relevant to this study

• Dr. Daner
  – None

• Dr. Domson
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• Dr. Isaacs
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Background:

- Mini C-arm commonly used during fracture reduction in our emergency department

Advantages:
- Convenient/portable
- Relatively little radiation emission - compared to x-ray (Lee 2011) and standard fluoro (Tuhoey 2011, Badman 2005, Thompson 2007)
  - May not hold true for newer equipment with better image quality
- Device operation by physician (control over positioning)
- Fluoro function allows more complete evaluation of fracture pattern and alignment
- Potential to improve the quality and ease of fracture reduction
- Decrease need for repeat reduction attempts (Lee 1994)
Background:

- Internal debate:
  Adequacy of mini C arm imaging/ necessity of formal post-reduction imaging following reduction of wrist fractures.
  - Expense of formal post-reduction x-rays
  - Extra time
  - Extra radiation
  - Barrier to ED throughput
Background:

- Mini C-arm previously shown effective in evaluating post reduction extra articular distal radius fractures in the pediatric population 15 years ago (Sharieff 1999)
Objective:

- Evaluate the adequacy of mini C-arm fluoroscopy in evaluating post-reduction alignment of distal radius fractures
  - Adult population
  - All distal radius fractures, including intra-articular patterns
Methods:

• Imaging prospectively collected for 60 consecutive* distal radius fractures that required reduction at our level 1 academic trauma center
  – October 2013 - January 2015

• Consults initially seen by PGY2 resident with upper level resident and attending oversight

• Formal “injury” radiographs were obtained to assess for fracture, determine fracture pattern, and determine the need for reduction
  – Fractures not requiring reduction were excluded from study

* When mini C-arm functional
Methods:

• Fracture reduction typically accomplished with aid of mini C-arm (OrthoScan HD 1000) at various points during the reduction

• Operation of mini C-arm unit and reduction performed by junior resident with graduated responsibility (+/- upper level immediate supervision)

• Following reduction, a well molded sugar tong splint (10-12 layers of plaster thick) applied
Methods:

• Mini C-arm then used for verification of adequacy of reduction after splinting prior to ordering formal post-reduction radiographs.

• Residents instructed how to obtain AP, lateral, and oblique views of wrist and provided diagram demonstrating these views
  – These 3 views saved with mini C-arm

• Formal post-reduction radiographs then obtained
Methods:

• Images for each imaging modality were later evaluated independently by:
  – Three orthopaedic trauma surgeons
  – Three hand surgeons
  – One radiologist

• Two separate surveys (one mini C-arm, one x-ray) created on a survey software to record responses (Survey Monkey)
  – Imaging stripped of patient identifiers
  – Order of patients randomized between the two surveys
  – Two or three views for each imaging modality used for each patient in the two surveys (sometimes oblique views were not obtained)
Methods:

• Viewers graded:
  – Subjective: positioning, confidence in assessment of reduction, and need for additional imaging
  – Objective: estimated the articular congruence, distal radius tilt, radial height

• Cumulative logistic regression model was used to determine if the responses from the mini C-arm differed from X-ray
Results:

- 60 distal radius fractures reduced and splinted in 57 patients
- 19 male, 38 female
- Average age of 50 yrs (19-92)
### Results:

<table>
<thead>
<tr>
<th>Item</th>
<th>Comparison</th>
<th>OR (95% CI)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Positioning (AP)</strong></td>
<td>Suboptimal vs (Adequate, Perfect)</td>
<td>2.42 (1.55, 3.76)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>(Suboptimal, Adequate) vs. Perfect</td>
<td>1.12 (0.78, 1.61)</td>
<td>0.539</td>
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<tr>
<td><strong>Positioning (Lateral)</strong></td>
<td>Not Confident vs (Adequate, Perfect)</td>
<td>1.19 (0.87, 1.62)</td>
<td>0.273</td>
</tr>
<tr>
<td></td>
<td>(Suboptimal, Adequate) vs. Perfect</td>
<td>0.89 (0.59, 1.35)</td>
<td>0.597</td>
</tr>
<tr>
<td><strong>Fracture Reduction</strong></td>
<td>Not Confident vs (Neutral, Confident, Very Confident)</td>
<td>1.97 (1.19, 3.26)</td>
<td>0.009*</td>
</tr>
<tr>
<td></td>
<td>(Not confident, Neutral) vs. (Confident, Very Confident)</td>
<td>1.65 (1.18, 2.30)</td>
<td>0.004*</td>
</tr>
<tr>
<td></td>
<td>(Not confident, Neutral Confident) vs. Very Confident</td>
<td>0.99 (0.69, 1.43)</td>
<td>0.973</td>
</tr>
<tr>
<td><strong>Articular Step-off</strong></td>
<td>0mm vs (1mm, 2mm, &gt;2mm)</td>
<td>1.50 (1.13, 1.99)</td>
<td>0.005*</td>
</tr>
<tr>
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<td>(0mm, 1mm) vs (2mm, &gt;2mm)</td>
<td>1.12 (0.84, 1.51)</td>
<td>0.438</td>
</tr>
<tr>
<td></td>
<td>(0mm, 1mm, 2mm) vs (&gt;2mm)</td>
<td>1.34 (0.93, 1.92)</td>
<td>0.113</td>
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<tr>
<td><strong>Volar/Dorsal Tilt</strong></td>
<td>&gt;20 deg. volar vs. (10 deg. volar, Neutral, 10 deg. dorsal, &gt;20 deg. dorsal)</td>
<td>0.88 (0.24, 3.17)</td>
<td>0.841</td>
</tr>
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<td>(&gt;20 deg. volar 10 deg. volar) vs. (Neutral, 10 deg. dorsal, &gt;20 deg. dorsal)</td>
<td>1.08 (0.71, 1.64)</td>
<td>0.726</td>
</tr>
<tr>
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<td>(&gt;20 deg. volar 10 deg. volar, Neutral) vs. (10 deg. dorsal, &gt;20 deg. dorsal)</td>
<td>1.13 (0.82, 1.55)</td>
<td>0.466</td>
</tr>
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<td>(&gt;20 deg. volar vs. deg. volar, Neutral, 10 deg. dorsal) vs. &gt;20 deg. dorsal</td>
<td>1.39 (0.77, 2.52)</td>
<td>0.271</td>
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<tr>
<td><strong>Radial Height (Loss)</strong></td>
<td>None vs. (&lt;5mm, 5-10mm, &gt;10mm)</td>
<td>1.75 (1.20, 2.55)</td>
<td>0.004*</td>
</tr>
<tr>
<td></td>
<td>(None, &lt;5mm) vs. (5-10mm, &gt;10mm)</td>
<td>1.17 (0.88, 1.54)</td>
<td>0.278</td>
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<td></td>
<td>(None, &lt;5mm, 5-10mm) vs. &gt;10mm</td>
<td>0.34 (0.89, 2.03)</td>
<td>0.165</td>
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<tr>
<td><strong>Treatment decision</strong></td>
<td>Need further imaging vs. Adequate</td>
<td>1.90 (1.34, 2.69)</td>
<td>&lt;0.001*</td>
</tr>
</tbody>
</table>
Results:

• X-ray was favored over the mini C-arm in the subjective assessment in determining the AP positioning, fracture reduction, and treatment decision (P<0.001, P=0.013, and P<0.001, respectively)

  – Odds mini C-arm AP imaging judged to be “Suboptimal” compared to “Adequate” or “Perfect” was 2.42 times higher (95% CI: 1.55, 3.76) than X-ray

  – Confidence in evaluation of fracture reduction with mini C-arm imaging had 1.97 times higher odds (95% CI: 1.19, 3.26) to be rated “Not confident” compared to all other options

  – Odds that further imaging was needed to guide treatment decisions imaging was 1.90 times higher for mini C-arm imaging (95% CI: 1.34, 2.69) than for X-ray
Results:

- Objective parameters:
  - Between imaging modalities, there was a difference in grading of articular step-off and loss of radial height ($P=0.004$ and $P=0.022$, respectively)
    - Compared to x-ray, mini C-arm imaging had 1.50 times higher odds (95% CI: 1.13, 1.99) of observing an articular step-off of 0 mm when compared to any other length.
    - Compared to x-ray, mini C-arm had 1.75 times higher odds (95% CI: 1.20, 2.55) of observing no radial height loss compared to any other option.
Results:

• No statistical difference in lateral positioning between modalities or estimated dorsal/volar tilt.
Discussion:

• We did not support our hypothesis

• X-ray preferred by most evaluators
  – AP positioning, reduction assessment, treatment decisions

• Objective measures
  – Similar amount of agreement and disagreement between the two imaging modalities

"Notice all the computations, theoretical scribblings, and lab equipment. Norm… Yes, curiosity killed these cats."
Limitations:

• Actual post-reduction alignment unknown
  – Comparing agreement between two different imaging modalities, not to a known value.

• Panel grading imaging did not have control over mini C-arm positioning, as would be the case in clinical practice

• Reliance on junior residents for imaging
  – Not all imaging optimally positioned
  – Rushed, busy residents
  – Not saving optimal imaging
  – May not know true lateral positioning
Conclusions:

• X-ray favored by most evaluators

• Measurements of objective parameters assessing reduction adequacy varied as often as they agreed.

• Post-reduction formal x-ray considered local standard of care for reduction assessment, but if two imaging modalities differ, impossible to know which is a truer representation of the actual fracture alignment.


Thank You