Does Adding Computed Tomography Change the Diagnosis and Treatment of Tillaux and Triplane Pediatric Ankle Fractures?

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Computed tomography (CT) has been deemed a necessary part of management for Tillaux and triplane pediatric ankle fractures. However, no previously published study has attempted to quantify its usefulness in changing management. Six third-party, blinded orthopedic surgeons (F.A.L., E.N.K., D.M.P., K.J.K., D.S.F., K.A.E.) were randomly assigned to evaluate 24 pediatric Tillaux or triplane fractures with plain radiographs; after 6 months, they were again randomly assigned to evaluate the 24 radiographs plus CT scans, totaling 144 third-party, blinded evaluations. Intra- and interobserver agreements were assessed via correlation coefficient analysis. Evaluation of CT scans changed the original diagnosis of fracture type from Tillaux to triplane fracture in 7 (4.9%) of 144 evaluations. Inter- and intraobserver agreements regarding primary treatment plans did not significantly differ between radiographs and radiographs plus CT scans (0.5 vs 0.4, respectively; P>0.05). The addition of CT did not significantly change the impression of the amount of displacement per case. By adding CT, more patients who were assigned nonoperative management were reassigned to operative treatment (P=0.033). Adding CT, although it may influence the decision to operate on Tillaux and triplane fractures, may not be as useful as previously thought.

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doi: 10.3928/01477447-20120123-11
Distal tibial fractures account for approximately 5% of pediatric fractures and 15% of physeal injuries and are twice as common in boys (Figure 1).\textsuperscript{1-3} When treating children with ankle fractures, 2 important goals exist: (1) achieving a satisfactory reduction; and (2) avoiding physeal arrest to minimize the risks of angular deformity, early arthrosis, leg-length inequality, and joint stiffness.\textsuperscript{4} The fusion pattern of the distal tibia’s epiphysis explains the configuration of the fragments in triplane and Tillaux ankle fractures. These patterns of injury result from a supination–eversion or external rotation force, typically in patients with a mean age of 13.5 years.\textsuperscript{5,6}

Although plain radiography has been cited as the mainstay in the diagnosis of pediatric ankle fractures, computed tomography (CT) has been cited as a useful adjunct for the evaluation of intra-articular pediatric ankle fractures.\textsuperscript{7,9} The spatial relation of major fracture fragments may be appreciated by examining the axial, sagittal, and coronal plane reconstructions, in addition to offering important information regarding articular splits and depressions, along with fracture comminution and alignment (Figure 2).\textsuperscript{6,10,11}

To our knowledge, although previous retrospective series have reported that CT is a necessary adjunct in treating Tillaux and triplane ankle fractures, no previously published study has quantitatively assessed CT as a useful adjunct to plain radiographs in this setting.\textsuperscript{9,12} The current study outlines the influence of adding CT to plain radiographs compared with radiographs alone in the diagnosis, decision-making process, and treatment of Tillaux and triplane ankle fractures. Based on previous literature, our null hypothesis for this study was that CT provides a useful adjunct in the decision-making process in the treatment of Tillaux and triplane pediatric ankle fractures. Thus, using intra- and interobserver agreements, our hypothesis was that there should be an increase in agreement when CT is added to plain radiographs.

**MATERIALS AND METHODS**

Between January 2001 and January 2003, an initial diagnostic code search for a diagnosis of Tillaux or triplane fracture was performed. Inclusion criteria were cases with complete plain radiographic and CT series to create the radiographic library for analysis and cases that were not treated by any of the 6 third-party, blinded evaluators (F.A.L., E.N.K., D.M.P., K.J.K., D.S.F., K.A.E.). A total of 24 cases met the criteria for inclusion. Cases without a CT scan and those that went immediately to the operating room were excluded.

Evaluation, assessment, and data collection were performed by 6 blinded, third-party orthopedic surgeons in a test/retest experimental design. Cases were assigned in a randomized fashion. Radiographic review was performed on 2 separate occasions with a 6-month interval between. Plain radiographs alone were assessed on the first occasion, and, on the second occasion, plain radiographs plus CT were assessed, totaling 144 evaluations. Following each plain radiograph review, a questionnaire was administered asking the reviewer to determine diagnosis (Tillaux versus triplane), amount of displacement, treatment plan (closed reduction with casting, closed reduction with percutaneous pinning [CRPP], or open reduction and internal fixation [ORIF]). The treatment plan was kept more general to avoid further subgroups of treatment. For example, CRPP was deemed those managed via Kirschner wires or via cannulated screws, and ORIF was deemed any open reduction combined with any type of fixation. Keeping the groups general provided for a more consistent and less confusing analysis, avoiding bias and removing surgeon preference as a variable. Following each plain radiograph plus CT review, a questionnaire was administered to determine changes in diagnosis, perceived displacement, and treatment plan. All radiographs provided were de-identified, and questionnaires were completed within 30 minutes of film review as a study requirement.

Statistical analysis was performed with SPSS version 18.0 software (IBM, Inc, Armonk, New York). Inter- and intraobserver agreement were analyzed via intraclass correlation coefficient (ICC), interpreted as follows: poor (0-0.2), fair (0.3-0.4), moderate (0.5-0.6), strong (0.7-
0.8), and almost perfect (>0.8) (Table 1). Categorical data were analyzed via Fisher’s exact test. Significance was set at $P < .05$.

**RESULTS**

In 7 (4.8%) of 144 evaluations, CT scan changed the original diagnosis of fracture type from Tillaux to triplane. Using an ICC to evaluate patients with plain radiographs vs plain radiographs plus CT, inter- and intraobserver agreement for classifying fracture type were 0.73 and 0.43, indicating strong and fair-to-moderate agreement, respectively; no significant difference was observed between agreements ($P = .05$).

When comparing treatment chosen with and without the addition of CT scan to plain radiographs, inter- and intraobserver agreements were 0.5 and 0.4, indicating moderate and fair agreement, respectively; no significant difference was observed between agreements ($P > .05$). After reviewing CT scans, an additional 19 (13%) of 144 evaluations ($P = .033$) that were initially assigned nonoperative management were reassigned to operative management (6 to CRPP; 13 to ORIF) (Table 2; Figure 3). In the operative group, when CT scans were added to plain radiographs, no significant increase was seen in the proportion of cases assigned ORIF vs CRPP ($P < 1.0$) (Figure 4).

Plain radiographic evaluation was the study most frequently cited as having the greatest influence on treatment (68%), followed by axial CT (11%), coronal CT (8%), and sagittal reconstruction (6%). The addition of CT scan to radiographic evaluation did not significantly change the impression of the quantity of displacement per case (Table 3).

**DISCUSSION**

Typically occurring in patients aged approximately 12 to 14 years, Tillaux fractures (Salter III fractures of the anterolateral portion of the tibia) and triplane fractures (Salter IV fractures that have components in the sagittal, coronal, and transverse planes) can be a diagnostic challenge. Articular displacement of >2 mm is generally considered an indication for reduction of the articular surface. Misdiagnosis and treatment that does not produce anatomic reduction can result in premature physeal closure and the aforementioned risks of deformity. Ertl et al reported that malreduction of the articular surface of >2 mm has been correlated with poor long-term out-

<table>
<thead>
<tr>
<th>Intraclass Correlation Coefficient Interpretation Values</th>
<th>Agreement Value</th>
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<tbody>
<tr>
<td>Almost perfect</td>
<td>&gt;0.8</td>
</tr>
<tr>
<td>Strong</td>
<td>0.7-0.8</td>
</tr>
<tr>
<td>Moderate</td>
<td>0.5-0.6</td>
</tr>
<tr>
<td>Fair</td>
<td>0.3-0.4</td>
</tr>
<tr>
<td>Poor</td>
<td>0-0.2</td>
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<table>
<thead>
<tr>
<th>Treatment Plan Based on Radiographic Evaluation</th>
<th>%</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plain Radiographs</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td>Plain Radiographs + CT</td>
<td>39</td>
<td>.033</td>
</tr>
<tr>
<td>Operative</td>
<td>48</td>
<td></td>
</tr>
<tr>
<td>CRPP</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>ORIF</td>
<td>33</td>
<td></td>
</tr>
</tbody>
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Abbreviations: CRPP, closed reduction with percutaneous pinning; CT, computed tomography; ORIF, open reduction internal fixation.
comes, with 7 of 15 patients having residual symptoms after 3 to 13 years of follow-up. Rapariz et al9 noted similar conclusions, reporting that CT was a mandated necessary step of management in this fracture cohort. Accepted modes of treatment include casting, percutaneous reduction with wire or screw fixation, and ORIF.10-21

Our data show that when presented with the same plain radiographic work-up, reviewers generally agreed on the classification of the fracture. However, the addition of CT scans had the potential to significantly alter the treatment plan. One of the major findings in our study, specific reasons (ie, location of fracture lines relative to the weight-bearing surface, newly recognized fractures lines on CT, rotational aspect) would have offered insight into the significant change from a nonoperative to operative treatment plan. Furthermore, more pointed reasons, such as avoiding the risk of future complications in this pediatric complication as a reason for surgery, may have also proved helpful.

**Table 3**

<table>
<thead>
<tr>
<th>Surgeon No.</th>
<th>Plain Radiographs</th>
<th>Plain Radiographs + CT</th>
<th>Change*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.7 ± 2.1</td>
<td>1.2 ± 2.0</td>
<td>−0.5</td>
</tr>
<tr>
<td>2</td>
<td>3.4 ± 3.2</td>
<td>3.5 ± 2.3</td>
<td>0.1</td>
</tr>
<tr>
<td>3</td>
<td>1.6 ± 1.1</td>
<td>2.1 ± 1.8</td>
<td>0.5</td>
</tr>
<tr>
<td>4</td>
<td>1.5 ± 0.9</td>
<td>1.6 ± 1.1</td>
<td>0.1</td>
</tr>
<tr>
<td>5</td>
<td>2.4 ± 2.5</td>
<td>1.9 ± 1.5</td>
<td>−0.5</td>
</tr>
<tr>
<td>6</td>
<td>2.7 ± 2.3</td>
<td>2.1 ± 0.7</td>
<td>−0.6</td>
</tr>
</tbody>
</table>

Abbreviation: CT, computed tomography. *No significant differences were observed.

change to operative management. One of the major findings in our study, specific reasons (ie, location of fracture lines relative to the weight-bearing surface, newly recognized fractures lines on CT, rotational aspect) would have offered insight into the significant change from a nonoperative to operative treatment plan. Furthermore, more pointed reasons, such as avoiding the risk of future complications in this pediatric complication as a reason for surgery, may have also proved helpful.

**CONCLUSION**

Despite the established literature reporting CT scan as a necessary adjunct to the treatment of Tillaux and triplane pediatric ankle fractures, no prior study quantifies its usefulness. Data from our correlation study rejected our null hypothesis, exhibiting little benefit to CT as a necessary adjunct in this fracture cohort. However, although a blinded, third-party evaluative, test/retest experimental design offers valuable information, a prospective, randomized trial may offer a more definitive look at the true usefulness of CT in assessing pediatric ankle fractures.

**REFERENCES**


