A BIOMECHANICAL COMPARISON OF THREE PIN CONFIGURATIONS FOR STABILIZATION OF PEDIATRIC SUPRACONDYLAR HUMERUS FRACTURES.

S. Lee^, A. Mahar*, D. Miesen^, P. Newton*

^ Orthopedic Biomechanics Research Center, Children’s Hospital – San Diego, San Diego, CA, USA
* Department of Orthopedic Surgery, University of California – San Diego, San Diego, CA, USA

INTRODUCTION
Most displaced pediatric extension type supracondylar humeral (SCH) fractures occur due to straight armed impacts associated with falling from skateboards, scooters and rollerblades. These injuries are often treated by closed reduction and percutaneous Kirschner (K) wire fixation. Type III fractures are characterized by posterior fragment translation with posteromedial displacement more common than posterolateral translation. Crossed medial/lateral pins or two parallel lateral pins are common clinical configurations. Biomechanical data suggest crossed pins are more stable for internal rotation. However, the medial pin has been associated with ulnar nerve injury and impingement. Previous tests examining the stability of divergent lateral pins indicated poor fixation for internal rotation tests when the pins were crossed at the fracture level (Figure 3). Internal rotation of the fragment can lead to the commonly reported cubitus varus deformity. A new divergent lateral pin configuration may increase stability compared to parallel placement and avoid medial pin insertion.

PURPOSE
To compare a new configuration of K-wire insertion (divergent lateral pins) to standard configurations (crossed and parallel lateral pins) in SCH fracture stability.

METHODS
Simulated transverse SCH fractures were created in nine synthetic pediatric humeri at a clinically common level. Each SCH fracture was stabilized with two 1.5mm diameter K-wires in crossed, parallel lateral and divergent lateral configurations (Figure 1). An alignment rig assured identical pin placement for each configuration in every model. Relative angles for pin placements were confirmed fluoroscopically.

The humerii underwent stability testing in extension, varus and valgus bending, as well as axial torsion. An MTS 858 testing machine applied 5 mm displacement at 0.5mm/s to the distal fragment in cantilever bending. Axial rotation was performed between 10° of internal and external rotation at 0.5 deg/s. The loading test order was randomized across pin configurations. The order of pin configurations was also randomized across humerii. Force, displacement, torque and angle were measured at 10Hz. Stiffness values were calculated for each direction and compared between pin configurations with a one-way ANOVA and a Tukey’s post-hoc correction.

Figure 2: Configurations for each fragment

Crossed  Parallel  Divergent
RESULTS AND DISCUSSION

There was no permanent displacement of the fracture, loss of fixation or pin deformation. A typical curve is shown in Figure 2. In extension, the two lateral pin configurations were stiffer than the crossed configuration. Varus stiffness was greatest with divergent lateral pins, while crossed and parallel were comparable. Crossed and divergent were stiffer than the parallel pattern in valgus. For internal/external rotation, crossed pins were stiffer than divergent and parallel configurations. In all loading conditions the divergent pins were equivalent or stiffer than parallel pins (Table I).

<table>
<thead>
<tr>
<th></th>
<th>Extension (N/mm) (p&lt;0.002)</th>
<th>Varus (N/mm) (p&lt;0.003)</th>
<th>Valgus (N/mm) (p&lt;0.000)</th>
<th>Int Rot (Nm/ deg ) (p&lt;0.000)</th>
<th>Ext Rot (Nm/deg) (p&lt;0.000)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5.3 + 1.1</td>
<td>7.2 + 1.2</td>
<td>7.6 +1.7</td>
<td>.23 + .03</td>
<td>.17+ 0.3</td>
</tr>
<tr>
<td></td>
<td>12.9 + 2.0</td>
<td>12.0 + 1.8</td>
<td>14.8 + 2.5</td>
<td>.10 + .01</td>
<td>.08 + .03</td>
</tr>
<tr>
<td></td>
<td>13.7 + .8</td>
<td>6.8 + 2.2</td>
<td>13.2 + 4.5</td>
<td>.14 + .03</td>
<td>.10 + .02</td>
</tr>
</tbody>
</table>

Table I – Stiffness values for each configuration (bold = p <0.05).
(Note: For each load condition, the bold values were statistically similar)

Crossed pinning of SCH fractures is the most secure method of fixation for internal/external rotation. However, laterally placed divergent pins crossing the fracture site on either side of the olecranon fossa protect the ulnar nerve and provide nearly equivalent overall stability. Comminuted fractures that require maximal stability should be considered for crossed pinning, with the understanding of potential ulnar nerve injury. For lateral fixation cases, a divergent pin configuration provides greater fracture stability than parallel lateral pins. These data oppose what has been reported previously in the literature for divergent pin stability. Previous placement only fixed the medial column and crossed the pins at the fracture site (Figure 3).

The new configuration emphasizes pin placement in the medial and lateral columns of the humerus and crossing the pins as far distal and lateral as possible to maximize the stabilization lever arm (See Figure 1).

REFERENCES


ACKNOWLEDGEMENTS

This research was funded by the Children’s Hospital Orthopedic Education and Research Fund.