Safe Zone for Superolateral Entry Pin into the Distal Humerus in Children: A MRI Analysis

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Introduction

- Radial nerve is at risk for injury during placement of pins, wires or screws around the lateral aspect of the distal humerus
Introduction: Iatrogenic Nerve Injury Around the Elbow with External Fixators

• In adults, incidence 0% - 43%
  – Radial nerve most at risk
• In children, true incidence unknown

Tetsworth Orthop Clin North Amer 1991
Stavlas Injury 2003
Li Chin J Traumatol 2005
Makarov J Pediatr Orthop 1997
Marcu J Pediatr Ortho 2011
Dal Monte J Pediatr Orthop 1985
Introduction: Radial Nerve Course Around the Distal Humerus

- In adults, well described
  - Absolute distance
  - Percentage
  - Proportionate
  - Anatomical-Topographical Atlas

Kamineni Clin Anat 2009
Fleming Clin Anat 2009
Guse Clin Orthop Relat Res 1995
Cox Clin Anat 2010
Artico Surg Radiol Anat 2009
Carlan J Hand Surg Am 2007
Foxall Reg Anesth Pain Med
Clement Surg Radiol Anat 2010
Chaudhry J Shoulder Elbow Surg 2008

Gausepol Injury 2000

ATLAS
FOR THE INSERTION
OF TRANSOSSEOUS WIRES
AND HALF-PINS
ILIZAROV METHOD
Introduction: Radial Nerve Course Around the Distal Humerus in Children

- Described anecdotally
- Reference system should be based on
  - Proportional measurement unit
  - Anatomic structure
    - Visible
    - Palpable
    - Readily identified radiographically intra-op

From: A Demiglio
Purpose

To map the position of the radial nerve in relation to the distal humerus in a pediatric population and describe a reliable anatomic safe zone based on a simple method that can be used intraoperatively to enhance safe placement of lateral pins/wires/screws.
Methods

- Elbow MRIs and associated elbow radiographs evaluated
  - 3 to 17 yo (mean 8.8 yrs ± 4.3 yrs)
  - 11 yr period
- MRI- 1.5 T magnet
- All MRIs performed within 3 months of X-rays
Fig. 1 The study patients.

Methods

32 MRIs for 30 patients

9 MRIs Excluded

23 MRIs for 22 Patients Included

- 3 Patients Too Young
- 4 Inadequate MRIs
- 1 No X-Rays
- 1 Cubitus Varus Deformity

Diagnosis
- 16 Fractures
- 4 Soft tissue injury
- 2 Cellulitis
- 1 Normal
Methods

• 3 Observers
  – 1 ped ortho surgeon
  – 2 senior radiology residents
• Evaluated MRIs to visualize nerve in consensus
• PACS axial and coronal T1-weighted images preselected using cross-reference tool
• All measurements performed twice
Transepicondylar Distance (TED) used to provide a proportional parameter for each individual, independent of age and size.
Methods

Midcoronal T1-weighted MRI
Methods

At 0% TED

- Anterior
- Posterior

At 50% TED
Methods

- Lateral Supercondylar Ridge Line (LSCRL)
  - Drawn tangentially to the lateral supracondylar ridge

\[
\%\ TED = \frac{a}{TED} \times 100
\]
Results

• Interobserver/intraobserver reliability
  – ICC 0.65 to 0.99

• TED- MRI vs. AP Radiograph
  – Increases with age
  – X-ray and MRI measurements
    • Mean difference 1.5mm (P < 0.02)
Results

<table>
<thead>
<tr>
<th>% TED</th>
<th>Radian nerve angle (mean, range)</th>
<th>Radian nerve distance (mean, range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% TED</td>
<td>54° (35° to 87°)</td>
<td>9.5 mm (3 to 26 mm)</td>
</tr>
<tr>
<td>50% TED</td>
<td>41° (24° to 63°)</td>
<td>7 mm (3 to 16 mm)</td>
</tr>
</tbody>
</table>
Results

• At point X, where supracondylar ridge diverges from LSCRL
  – 18 MRIs
  – Mean %TED: 60% (range 51% to 76%)
  – Radian nerve angle: 39° (range 51° to 61°)
  – Radian nerve distance: 6 mm (range 2 to 10 mm)
Discussion

• Kamineni et al. *Clin Anat* 2009
  – In adults, radial nerve is no closer than 1.4 x TED projected proximally from lateral epicondyle
  – Direct lateral pin placement safe if within 70% of TED
Conclusions

• Limitations
  – Small number of MRIs
  – Pathology in most studies
  – Arm position not standardized
  – More proximal anatomy not included on MRI
Conclusions

- Percutaneous lateral entry of k-wires or half-pins should be placed caudal to a point where the lateral supracondylar ridge diverges from the LSCR line, either at or directly posterior to the ridge, and aiming slightly anteromedial.
Thank you