

## ACS 2025 Surgeons and Engineers: A Dialogue on Surgical Simulation Meeting

O-06

### Research In-Progress

#### The Michigan Elbow: Design and Preliminary Evaluation of a Pulled Elbow Task Trainer

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**Introduction:** Radial head subluxation (RHS), also known as pulled elbow or nursemaid's elbow, is a common injury in young children. RHS occurs as the annular ligament of the elbow slips over the radial head of the radius becoming trapped within the radiohumeral joint. While reducing the subluxation is a simple procedure, many physicians and medical students rarely get the opportunity to treat RHS. The novel nursemaid's elbow trainer enables instruction and practice in reducing radial head subluxation in clinical and classroom settings. The model incorporates 3D-printed hinging bones, print-in-place designs, and a reliable magnetic clicking system.

**Methods:** A model of a child's arm was used to create a silicon-based trainer embedded with a 3D-printed ligament-reducing mechanism. When the elbow is correctly reduced, the learner receives positive feedback in the form of an audible click and haptic feedback mimicking that of a reduced elbow. Two models, supination and pronation, were designed and evaluated. Twenty-one experienced pediatric (n=13) and Emergency Medicine (n=8) clinicians independently evaluated the simulators' physical attributes, realism, value, and relevance using a 14-item paper survey consisting of 4-point rating scales (4=highest). Participants' ability to complete reduction were self-reported using 5-point rating scales (5=very easy).

**Preliminary Results:** Reviews were positive for both models, with scores indicating adequate physical attributes,  $m=3.30, SD=0.54$  and  $m=3.27, SD=0.59$ , and high value  $m=3.47, SD=0.54$  and  $m=3.50, SD=0.52$  for supination and pronation, respectively, with mean scores that aligned with "Adequate realism, but could be improved." Suggestions included making the model smaller and improving haptics on reduction mechanism.

**Next Steps:** Preliminary findings indicate the novel simulator holds promise for training best practice techniques after refinement. Future research will target refinement, expanding evaluation, and developing a comprehensive curriculum and competency assessment program.

Table 1. Comparison of Supination and Pronation ratings,  $p > .05$

Checklist item	Supination (n=19) Mean (SD)	Pronation (n=19) Mean (SD)
Overall scale of arm relative to average patient	3.11 (0.58)	3.07 (0.59)
Anatomical landmark, tactility – medial condyle	3.26 (0.00)	3.25 (0.68)
Anatomical landmark, tactility – lateral humeral condyle	3.16 (0.77)	3.13 (0.81)
Stability/Ease of use of the base	3.47 (0.64)	3.42 (0.70)
<b>Physical Attributes, Average (4=maximum score)</b>	<b>3.30 (0.54)</b>	<b>3.27 (0.59)</b>
Realism of patient arm positioning on initial presentation ( <i>elbow slightly flexed, hand pronated</i> )	3.37 (0.50)	3.44 (0.52)
Pressure required for supination/reduction	2.84 (0.96)	3.06 (0.77)
Feel of the hand/wrist when reduced	2.45 (0.69)	2.63 (0.52)
Feel of the elbow when reduced	<b>2.26 (0.73)</b>	<b>2.29 (0.71)</b>
Feel of hand/wrist when reduced	2.63 (0.92)	2.62 (0.89)
<b>Realism of Experience, Average (4=maximum score)</b>	<b>2.81 (0.55)</b>	<b>2.92 (0.48)</b>
Grasp the elbow laterally over the radial head with the thumb of one hand, place the fingers of the same hand over the medial aspect of the elbow.	4.59 (0.62)	4.71 (0.47)
<i>FOR SUPINATION:</i> Supinate the forearm by grasping the forearm with one hand just proximal to the wrist until full supination is achieved. If reduction isn't felt, flex the elbow to ~100 degrees.	4.35 (0.86)	–
<i>FOR PRONATION:</i> Pronate the forearm by grasping the forearm with one hand just proximal to the wrist until hyperpronation (~120 degrees) is achieved or reduction felt.	–	<b>4.83 (0.41)</b>
<b>Ability to perform the above tasks (5=maximum score)</b>		
Value as a training tool (4=maximum score)	<b>3.47 (0.54)</b>	<b>3.50 (0.52)</b>
Value as a testing tool (4=maximum score)	<b>3.18 (0.95)</b>	<b>3.14 (1.03)</b>
Relevance to Practice (4=maximum score)	<b>3.59 (0.62)</b>	<b>3.63 (0.56)</b>
Global Rating (4=maximum score)	<b>2.27 (0.88)</b>	<b>2.45 (1.04)</b>
Preference as first method (% total)	<b>18.1%</b>	<b>81.9%</b>