

Predicting Distal Radius Remodeling in Pediatric Fractures Using an AI-Modified Friberg-Based Model: Model Development and Retrospective Validation

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INTRODUCTION: Pediatric distal radius fractures often remodel over time, but the rate and extent vary. Experienced clinicians often estimate remodeling heuristically or employ an objective but over-simplified exponential decay model developed by Friberg. We hypothesized that natural-language AI could be used to update the equation according to first principles and integrate known modifiers of remodeling potential as predictive parameters.

METHODS:

Model development: We prompted a natural-language AI to update the Friberg equation with the following additional parameters: age, sex, deformity magnitude, and distance from the physis and tuned the parameters to fit a small pilot data set.

Model validation: We retrospectively analyzed 176 pediatric non-operative distal radius fractures (mean age 8.4 ± 4.8 yrs; 58% male) with serial angular measurements (mean 1.6 per subject, range 1–6). For each case, we compared observed and model-predicted angulation values across timepoints using intraclass correlation (ICC) and linear regression.

RESULTS: The AI generated an exponential decay function where age, sex, deformity magnitude, and distance from the physis modify the value of the decay parameter consistent with known effects (Figure 1). Validation data showed good agreement between predicted and observed angles: ICC = 0.76; regression analysis indicated low model bias: slope 0.93 (95% CI: 0.90-0.97), intercept 0.59 (95% CI: 0.22-0.95), $p < .001$, and low residuals: $R^2 = 0.91$. (Figure 2). Subgroup analyses stratified by follow-up duration and number of radiographic observations confirmed consistency ($R^2 > 0.87$ across strata). For a representative case (13M, 14° initial deformity, 45mm from physis), the model predicted angulation of 9.5° at 6 weeks and 6.5° at 3 months, with an absolute error ranging from 0.08° to 2.54° .

DISCUSSION AND CONCLUSION: With appropriate prompts, natural-language AI can be used in orthopedics to generate clinically useful predictive tools from first principles. While natural-language AI itself is ultimately a “black-box,” the output need not be. The equation generated was validated on a sizeable pediatric dataset, demonstrating the model accurately predicts remodeling trajectories in pediatric distal radius fractures using easily obtained clinical inputs. This tool may reduce unnecessary imaging and visits, improve individualized follow-up timing, and augment shared decision-making.

Figure 1: Expected angulation model

$$A(t) = A_0 \cdot \exp \left\{ -\frac{t}{0.019} \cdot \left[\alpha \cdot \left(0.034 \cdot 0.034 + \frac{0.034}{\left(1 + \frac{d}{1+age}\right)^{1/2.1}} \right) \cdot (1 + 0.0025 \cdot A_0) \cdot \max \left(0, 1 - \frac{age}{20} \right) \right] \right\}$$

where:

- $A(t)$ is expected angulation at time t (months)
- A_0 is initial angulation (degrees)
- d is unadjusted distance from physis (mm)
- $\alpha = \begin{cases} 1.5 & \text{if } age < 2 \\ 1 & \text{otherwise} \end{cases}$

Figure 2: Scatter plot of predicted angle versus observed with linear regression line

