# The Addition of Hand-Specific Skeletal Maturity Parameters Does Not Strengthen the Prediction of the Modified Fels Wrist System

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INTRODUCTION:

The Modified Fels Wrist system is potentially the most accurate clinically accessible skeletal maturity system utilizing hand or wrist radiographs. During development, parameters distal to the metacarpals were excluded. We attempted to further optimize the Modified Fels wrist system through the inclusion of hand parameters distal to the metacarpals.

METHODS:

Forty-three radiographic parameters were identified by evaluating AP hand parameters from the Fels and Greulich and Pyle (GP) skeletal maturity systems. Following univariate analysis for correlation and reliability, thirty-one hand parameters were evaluated on serial peripubertal AP hand-wrist radiographs. These were added to the eight parameters from the Modified Fels Wrist system and assessed with stepwise linear regression and generalized estimating equations to identify key radiographic and demographic parameters. The final model was compared to: 1) GP only, 2) Sanders Hand (SH) only, 3) age, sex, and GP, 4) age, sex, and SH, and 5) Modified Fels Wrist system.

RESULTS:

A total of 372 radiographs from 42 girls and 38 boys were included. Of the 39 parameters originally included, 9 remained in the combined Modified Fels Hand-Wrist system in addition to chronological age and sex. Three parameters are wrist specific and the remaining six are hand specific parameters. The Modified Fels Hand-Wrist system predicted skeletal maturity with a mean discrepancy of $0.27\pm0.25$ years, with a rate of 1.8% of outlier predictions more than one year discrepant from skeletal maturity. The Hand-Wrist system outperformed both GP and SH in predicting skeletal maturity ($p<0.001$). When compared to the Modified Fels Wrist system, the Modified Fels Hand-Wrist system performed similarly regarding skeletal maturity prediction and outlier rate ($P = 0.47$ and $P = 0.94$).

DISCUSSION AND CONCLUSION:

The addition of hand parameters to the existing Modified Fels Wrist system did not significantly improve the skeletal maturity prediction accuracy or outlier rate. Therefore it is unnecessary to include additional hand parameters in the system although they easily attainable on hand-wrist radiographs. When an AP hand-wrist radiograph is available, the existing Modified Fels wrist system is adequate to predict skeletal maturity.

Table 1: Comparisons to Modified Fels Hand-Wrist using predicted and true years from reaching 90% final height.

| | GP Only | Sanders Only | Age + Sex + GP | Age + Sex + Sanders | Modified Fels Wrist | Modified Fels Hand-Wrist |
|---|---|---|---|---|---|---|
| Mean prediction discrepancy ± SD, *yrs* | 0.52 ± 0.50 | 0.59 ± 0.45 | 0.35 ± 0.30 | 0.34 ± 0.30 | 0.30 ± 0.25 | 0.27 ± 0.25 |
| Mean prediction discrepancy (p-value ) | **<0.001** | **<0.001** | **<0.001** | **<0.001** | 0.470 | - |
| % of Outlier Predictions (>1 year off) | 24.5% | 21.0% | 4.3% | 3.5% | 1.9% | 1.8% |
| Outlier predictions (p-value) | **<.001** | **<0.001** | 0.065 | 0.146 | 1 | - |
| R$^2$ | 0.759 | 0.774 | 0.909 | 0.911 | 0.937 | 0.949 |

GP = Greulich and Pyle; SH = Sanders Hand; SD = standard deviation