Comparing Two Abbreviated Bone Age Assessment Methods to Greulich and Pyle and the Modified Fels Wrist System Using Serial Radiographs

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INTRODUCTION:

Accurate radiographic assessment of bone age is crucial in pediatric orthopaedic surgery. Two abbreviated methods of bone age assessment, the Shorthand Bone Age (SBA) Assessment and SickKids/Columbia (SKC) methods, were recently developed to serve as simpler and more efficient alternatives to the Greulich and Pyle (GP) Atlas. The SKC and SBA methods utilize a single radiographic criterion to assign ages. These methods have previously demonstrated substantial agreement with GP but have not been compared on a serial radiographic collection where performance can be more carefully assessed. To clarify their performance, we compared the two shorthand systems to GP, as well as the recent modified Fels wrist system, using a serial radiographic collection where heights were known for each subject to judge skeletal maturity.

METHODS:

Three hundred and forty-eight de-identified left hand-wrist radiographs of 42 females (7 to 15 years) and 38 males (9 to 16 years) from the Bolton-Brush Collection were assigned bone ages by two medical students using both abbreviated bone age methods. Inter-rater reliability and intra-rater reliability were evaluated in a collection of 20 radiographs and compared to a faculty member through Spearman's rank correlation coefficient analysis, prior to measuring the full dataset. The inter-rater reliability coefficients ranged from 0.90 – 0.92 for the SBA method and 0.89 – 0.98 for the SKC method. The intra-rater reliability coefficients ranged from 0.87 – 0.92 for the SBA method and 0.854 – 0.92 for the SKC method ($p<.001$ in all cases), indicating very good to excellent reliability. These radiographs were also previously assigned skeletal ages by a pediatric endocrinologist using the Greulich and Pyle Radiographic Atlas, had 90% final height data assigned, and had skeletal ages previously determined by the Modified Fels Wrist Method available for comparison. Both authors were blinded to original bone age assignments. After excluding cases with Shorthand scores at the youngest and oldest ends of the systems, we compared Pearson r values of the various skeletal maturity systems versus skeletal maturity using the 90% final height standard.

RESULTS:

In both raters, the SBA abbreviated bone age assessment method resulted in a strong, positive correlation with 90% final height (p-value <0.01) using Spearman's rank correlation coefficient analysis and was comparable to Greulich and Pyle and modified Fels wrist, while the SKC shorthand system had lower performance (Tables 1-2).

DISCUSSION AND CONCLUSION:

The Shorthand Bone Age (SBA) Assessment method had high correlation with the 90% Final Height skeletal maturity standard and performed comparably to Greulich and Pyle and modified Fels wrist, while the SickKids/Columbia (SKC) method did not. The relative ease of the SBA shorthand system, in addition to its relative performance, suggests potential utility. Further analysis and follow up clinical study is necessary to delineate the roles of these different systems.

TABLE I: SBA Method Compared to 90% Final Height

Males				
	Rater 1 SBA	**Rater 2 SBA**	**mFels Wrist**	**Greulich and Pyle**
r value	0.95	0.96	0.98	0.96
p-value	**	**	**	**
Females				
	Rater 1 SBA	**Rater 2 SBA**	**mFels Wrist**	**Greulich and Pyle**
r value	0.95	0.98	0.94	0.98
p-value	**	**	**	**

**. Correlation is significant at the 0.01 level (2-tailed).
mFels Wrist = modified Fels wrist system

TABLE II: SKC Method Compared to 90% Final Height

Males				
	Rater 1 SKC	**Rater 2 SKC**	**mFels Wrist**	**Greulich and Pyle**
r value	0.76	0.68	0.98	0.89
p-value	**	**	**	**
Females				
	Rater 1 SKC	**Rater 2 SKC**	**mFels Wrist**	**Greulich and Pyle**
r value	0.89	0.85	0.94	0.90
p-value	**	**	**	**

**. Correlation is significant at the 0.01 level (2-tailed).
mFels Wrist = modified Fels wrist system