Use of Elbow Radiographs to Assess Skeletal Age in Scoliosis
Richard M. Schwend
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Skeletal maturity and remaining growth must be considered in the evaluation of the risk of curve progression in idiopathic scoliosis. Because spine films are not sensitive enough to measure the progression of skeletal maturity during the rapid growth phase of adolescence, many orthopedists use radiographs of the elbow and the method of Sauvegrain¹ to measure skeletal maturational changes during this time period. This French study compared the accuracy of a simplified method² of assessing skeletal age with traditional methods during the acceleration stage of growth in adolescents with idiopathic scoliosis.

The authors retrospectively evaluated data obtained between 1988 and 2006 from 100 boys and 100 girls, randomly selected from a group of 561 patients evaluated for idiopathic scoliosis who had been followed at six-month intervals, had a complete set of radiographs, and had known outcomes.

Skeletal maturity was measured using the “simplified olecranon method,” the method of Sauvegrain, and assessment of the triradiate cartilage found in the developing acetabulum. The simplified method of skeletal age assessment evaluates five evolving shapes of the developing olecranon ossification center that change over six-month time intervals using a lateral radiograph of the elbow.

The Sauvegrain method determines skeletal age from anteroposterior and lateral radiographs of the left elbow and is based on a 27-point scoring system evaluating four ossification centers. The triradiate cartilage of the developing acetabulum is monitored for fusion, which usually occurs midway through the rapid stage of growth. Radiograph interpretation was performed by three experienced observers blinded to patient information, other than gender. The 100 girls averaged 12.0±1.2 years of age (range 10.0-13.1), and the 100 boys averaged 13.9±1.0 years (range 12.2-15.5). The pubertal growth spurt began at an average skeletal age of 11 years in girls and 13 years in boys with an average annual standing height velocity of 7.2±0.8 cm/year (range 6.0-8.5 cm/year) in girls and 8.1±0.9 cm/year (range 6.0-10.0 cm/year) for boys.

Menarche occurred at an average chronological age of 13.11±1.03 years (range 11.0-16.0 years). There was excellent concordance between the simplified olecranon method and the Sauvegrain method, with an average concordance of r=0.977 for boys and r=0.938 for girls. The concordance between the three observers was equally excellent. Skeletal age corresponded within six months in 49% of boys and 51% of girls, and was advanced ≥6 months in approximately 25% and delayed by approximately 25% for both sexes. The triradiate cartilage closed when the olecranon apophysis had a rectangular shape in 61% of girls and 65% of boys and within six months before or after appearance of a rectangular shape in 88% of girls and 91% of boys, corresponding to a skeletal age of 12 years in girls and 14 years in boys.

The authors conclude that the morphological development of the olecranon represents a simple but reliable method of skeletal age assessment during the phase of peak height velocity.

Children with idiopathic scoliosis are especially at risk for curve progression if they are just entering the acceleration stage of their growth spurt. Those with scoliosis from no obvious cause that occurs before age 10 years are especially at risk for progression, with approximately 50% eventually receiving surgical treatment.3 Chronological age is not an adequate marker of skeletal maturity. In this study, in only about 50% of adolescents did the chronological age agree with the skeletal age within six months.

During the adolescent growth spurt there are few radiographic parameters to document the progression of skeletal maturity. The Risser sign, used by orthopedists to assess spinal maturity, is not sufficiently accurate during most of the pubertal growth period (so-called Risser grade 0). The initial appearance of the iliac crest apophysis ossification center, described by a Risser grade of 1, does not occur until after the peak of growth velocity. Triradiate cartilage closure occurs during the acceleration stage, but it is not always included on a spine radiograph due to concerns of pelvic radiation and is only a single point in time. Hand bone age measurements are a commonly utilized method for assessing skeletal maturity in children. However, they are less practical for assessing spinal maturity because they are not readily divided into six-month intervals and have required use of an atlas.4

The authors report a simplified method to evaluate the skeletal age of rapidly growing children through six-month intervals, corresponding to the usual interval at which at-risk patients are followed during this stage.

The simplified olecranon method of assessing skeletal age, utilizing a lateral radiograph of the elbow, was practical, precise, and reliable. During the important two-year acceleration stage of growth (11-13 years in girls and 13-15 years in boys) when the child remains at Risser 0, the olecranon underwent five different radiographic appearances, with a new shape every six months. The shapes included initial appearance of two ossification nuclei, a half-moon appearance, rectangular shape, beginning of fusion, and finally complete fusion. A rectangular-shaped olecranon ossification center corresponded to skeletal age 12 years in girls and 14 years in boys and to closure of the triradiate cartilage. Complete fusion of the olecranon heralded the beginning of the deceleration stage of height velocity and a much reduced risk of scoliosis progression. The triradiate cartilage closed about midway during the acceleration growth stage, at skeletal age 12 years in girls and 14 years in boys. Triradiate cartilage closure was a very precise maturity marker. Menarche typically occurred after growth velocity had peaked, but had a large chronological age range of 11-16 years. Spinal growth continues for two years after menarche, which was confirmed in this study. Curve progression was unlikely after menarche.

When evaluating children with scoliosis it is important to determine their skeletal maturity, especially when they are in the rapid stage of growth. The authors present a very simple, practical, and low-radiation method to do this.

Editors’ Note

Following the morphological sequence of five distinct images of the olecranon will make it easier for orthopedists to back up their therapeutic decisions for bracing or surgery.

References
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