Cobb Angle Measurement of Scoliosis Using Computer Measurement of Digitally Acquired Radiographs-Intraobserver and Interobserver Variability

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Study Design: We evaluated computer assisted digital measurement of radiographic parameters in patients with idiopathic scoliosis.

Purpose: To assess the reliability of digital measurements.

Overview of Literatures: Various authors analyzed scoliotic deformities by conventional radiographs, but very few studies have addressed the reliability of digital radiographic measurement using computer software.

Methods: Three independent, blinded observers measured 318 whole spine pre-operative antero-posterior radiograms of children with varying degrees of idiopathic scoliosis. Only one curve per radiograph was measured. Each observer measured the Cobb angle three times with a 1-week gap between each measurement. The computer system, picture archiving and communication system (PACS, PiViewSTAR version 5) was used in all cases. The end vertebrae were pre-selected to avoid this as a potential source of error. The results were statistically analyzed for intraobserver and interobserver reliability and variability.

Results: The 95% confidence intervals for intraobserver and interobserver variability were ± 1.30 and ± 1.260, respectively. There was better reliability in larger curves.

Conclusions: Measurement using a digitized system may help to minimize measurement discrepancies by eliminating an intrinsic cause of error.

Key Words: Scoliosis, Digital imaging, Cobb angle, Intraobserver and interobserver variability

Introduction

The Cobb angle is probably the most widely used parameter for quantifying the severity of scoliotic curvature[1]. This method must have satisfactory reliability and reproducibility to facilitate comparison within and between studies, and allow accurate treatment-directed assessment of deformity[2]. Numerous authors have performed comprehensive reliability analyses on other radiographic measures for scoliosis[3,4]. However, few studies have addressed the reliability of computer-assisted digital radiographic measurements in patients with scoliosis[2]. Digital imaging has many advantages in terms of convenience, portability, and ability to adjust contrast, brightness, and magnification, leading to increased accuracy of measurements compared to manual methods[2]. The current study measured the intraobserver and interobserver reliability of scoliotic measurements with digital images using computer software.

Materials and Methods

We measured 318 whole spine pre-operative, antero-pos-

terior radiograms from children with varying degrees of idiopathic scoliosis involving the spine. Only one curve per radiograph was measured. The child's age was arbitrarily classified into three groups: 0 to 6 years, 7 to 10 years, and more than 10 years; 178 radiograms were in patients >10 years old, 93 radiograms were in the 7 to 10 year age group, and 47 radiograms were in the <7 years age group. The curves were also divided into mild (<20°, n=180), moderate (20-40°, n=123) and severe (>40°, n=15) curves.

Three observers independently examined the radiograms. Simulating clinical conditions, the observers were of varying levels of experience and included a spine fellow and two spine surgeons who regularly measured Cobb angles on radiographs in the spine clinic. Each observer measured the Cobb angle three times each, and they were blinded regarding all previous measurements. The digitized computer system, picture archiving and communication system (PACS, PiView STAR ver. 5, Seoul, Korea) was used in all cases. PACS is a digitized system that stores radiographs and medical records. The installed software measures Cobb angle by drawing a line along the predetermined vertebral end plate on the screen. A minimum of one week between each measurement reduced memory effects on reproducibility. The end vertebrae were pre-determined to avoid this as a potential source of error.

Statistical analysis provided both intraobserver and interobserver variability and reliability in each age group for Cobb measurements. Both intra observer and interobserver reliability were accessed by calculating intraclass correlation coefficient (ICCC) (two-way mixed, random effect model, absolute agreement) according to the method described by Deyo et al.[5] The average ICCC gives interobserver reliability and single measure ICCC gives intraobserver reliability. The ICCC value can be arbitrarily interpreted as poor (<0.20), fair (0.21 to 0.40), moderate (0.41 to 0.60), substantial (0.61 to 0.80), and excellent (0.81 to 1.00)[6].

Table 1. Studies of measurement variability for the entire sample

	Single measure ICCC values (intra observer variability)	Mean	SD
Observer A	0.976	21.56	11.25
Observer B	0.970	21.94	11.99
Observer C	0.978	20.04	11.69

ICCC: intraclass correlation coefficient.

Results

The single measure ICCC values were excellent for all three observers for the entire sample, indicating low intraobserver variability and good reliability with the digitized measurement method (Table 1). The 95% confidence interval for intraobserver variability was 1.3°. The single ICCC values were excellent for all observers for all age groups generally, but was better for children <6 years, as were the average ICCC values (Table 2). The 95% confidence intervals for interobserver variability was 1.26°.

For mild curves, all observers showed variable single measure ICCC values, but average ICCC values were also similar. In the moderate curve group, observers A, B and C showed variable single ICCC values that were not significantly different (Table 2). The average ICCC value was similar to that of the mild curve group (Table 3).

For the severe curve group, the single ICCC values for all observers and the average ICC values were better than the other two groups-all ICCC values were excellent. There were no significant changes in intraobserver and interobserver reliability for all age groups and all curve severities.

Discussion

The reliability of radiographic measurement is crucial to treatment of idiopathic scoliosis[7]. The measurements assessed in this study are routinely used in clinical practice[8]. Digital radiograph analysis will become more common as the technology becomes increasingly popular and affordable. Contrast, brightness, and magnification can be manipulated with digital techniques. However, the reliability of the technology for measuring Cobb angles needs to be evaluated.

The average interobserver variability in our study was 1.26°, which is much less than those obtained for adolescent idiopathic scoliosis using manual methods[7,9]. The average intraobserver variability, 1.3°, was also much less than previous studies[7,9].

The authors tried to eliminate all intrinsic causes of error in our study. Because selecting the end vertebrae significantly affects intra-and inter-observer error[10,11], we preselected the end vertebrae to avoid this error. Uses of different protractors, markers/pencils of varying width, poor quality radiograms, are also intrinsic causes of error[2,8,10,11].

Table 2. Studies of measurement variability for the sample grouped according different age groups and curve severity

		Age groups (yr)			Curve severity (°)		
		0-6 n=47	7-10 n=93	>10 n=178	0-20 n=180	20-40 n=123	>40 n=15
Observer A	Single ICCC value	0.988	0.971	0.954	0.765	0.836	0.984
	Mean	23.64	20.34	21.52	14.99	26.38	58.09
Observer B	Single ICCC value	0.986	0.982	0.916	0.839	0.845	.0963
	Mean	22.75	21.16	21.99	15.20	26.69	60.08
Observer C	Single ICCC value	0.990	0.985	0.949	0.900	0.887	0.970
	Mean	20.98	19.16	20.11	13.36	24.94	56.37

ICCC: intraclass correlation coefficient.

Table 3. Average ICCC values signifying interobserver variability for different age groups and based on curve severity

Entire sample	0-6 yr	7-10 yr	>10 yr	0-20°	20-40°	>40°
0.986	0.994	0.988	0.967	0.882	0.914	0.989

ICCC: intraclass correlation coefficient.

Morrissy et al.[11] found a 6.3° interobserver variability and 2.8° intraobserver variability using a manual method that controlled intrinsic causes of variability. These factors do not play a role in digitalized curve measurements such as in our study. Using digital radiographs, we were able to manipulate and enhance contrast, sharpness, and brightness, thus enabling better visualization of details and more consistent results.

Kuklo et al.[2] found that digital measurement reduced intraobserver variability compared with manual measurements. Shea et al.[12] found digital measurement to be more precise for Cobb angle measurement by eliminating the sources of intrinsic errors using the digitized technique. Wills et al.[13] used manual measurements with preselected end vertebra to minimize the source of intrinsic error, and found a 0.994 overall correlation for manual and digitalized measurements.

Eliminating intrinsic variability may have helped to minimize measurement discrepancies. When these intrinsic factors are present (lack of computer programs and digital radiograms), the differences in ICCC measurements may be magnified.

The strength of our study is the use of 318 patient radiograms, measured in triplicate by 3 observers, for a total of 5724 measurements. The observers were blinded for all previous measurements and all possible sources of intrinsic error were excluded by using pre-selected end vertebrae and digitized programs. All observers were aware of the pur-

pose of their measurements and they may have competed among themselves to improve their precision. Although manual radiograms may have larger ,measurement discrepancies, we did not do a comparative study here. Also, extrinsic error was not measured in this study. The three main sources of extrinsic error are the position of the patient, the position of the radiographic tube, and the time of the day when the radiograph was made[11],

Conclusions

The results of this study demonstrate that intraobserver and interobserver variability for digitalized Cobb angle measurements were much lower than manual methods. Intrinsic sources of error must be reduced to minimize measurement discrepancies.

Acknowledgements

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