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ORIGINAL ARTICLE

Reliability of a Novel Cobb Protractor for Measuring the Cobb Angle of Radiograph in Scoliosis

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Objective To introduce a novel Cobb protractor and assess its reliability and rapidity for measuring Cobb angle in scoliosis patients.

Methods The novel Cobb protractor had two endplate markers. A measurement was performed just to align the two markers to each endplate of the curve. The Cobb angle on the posteroanterior radiographs of 24 patients clinically diagnosed with adolescent idiopathic scoliosis was measured by three orthopedic surgeons with both standard Cobb method and the new technique, and the time of measurement was recorded. Intraclass correlation coefficients (ICCs) were calculated to assess the reliability of the new method.

Results The time for a measurement with the new tool was approximately 10 seconds less than the time that used to finish a measurement with the standard method ($P < 0.05$). The overall mean Cobb angle for the major curve of the 24 patients was 47.8° . The mean overall intraobserver and interobserver ICC was 0.971 and 0.971 for the Cobb method group, while the overall intraobserver ICC and the interobserver was 0.985 and 0.979 for the new tool group.

Conclusions The novel Cobb protractor could perform quick measurement and measure almost all forms of radiographs. The Cobb protractor might be an ideal instrument to measure the Cobb angle.

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C OBB angle as a gold standard for evaluating the spine deformity was first raised by Joan Cobb in 1948.¹ The standard method for measuring the Cobb angle was to draw the superior and inferior lines parallel to the endplates of the vertebrae with a pencil and subsequently measure the angle between these two lines after drawing the perpendicular on physical

radiographs. It is an important radiographic parameter for orthopedic surgeon to make a therapeutic decision.

Recently with the development of digital imaging, orthopedic surgeons have to measure Cobb angle on digital radiographs displayed on the screen on occasion. However, it is not feasible to finish the measurement by the standard method. In some centers of spine surgery, to solve the problem the reliable computer software² and iPhone APP³ have been developed to meet the requirement of orthopedic surgeons. Due to the high cost of these equipments, these techniques cannot be widely used.

Hence, we introduced a new Cobb protractor for measuring Cobb angle directly without drawing line on either plain film or digital radiograph and identified its reliability for measuring Cobb angle in scoliosis patients.

PATIENTS AND METHODS

Patients

During 2011 and 2013, 24 adolescent idiopathic scoliosis (AIS) patients underwent operation in the Department of Orthopaedics of Peking Union Medical College Hospital. The Cobb angle from a posteroanterior radiograph was measured with a new Cobb protractor and standard method respectively. The mean age was 13.5 ± 2.3 years. The preoperative X-ray was selected if: (1) the patient was diagnosed as AIS; (2) the whole spine was shown on a single X-ray image; and (3) the endplate of the vertebrae could be clearly identified.

According to the AIS classification system of our hospital, the curve pattern of patients was classified as follows: 3 cases in I a, 3 cases in I b, 9 cases in II a, 3 cases in II b, 3 cases in II c, 2 cases in III a, and 1 case in III b. For each patient only the major curve was measured for the study. All of the 24 radiographs had both the plain films and digital copies. The identifying information of the patient on the radiograph was masked. The end vertebrae were preselected and marked on all radiographs to eliminate it as a source of error. All of the plain films were same in size.

Measurement method

Three independent orthopaedic surgeons who were familiar with the measurement method of Cobb angle were selected to finish the measurement. For each observer, both the standard manual Cobb measurement method and the new Cobb protractor were used to measure Cobb angle on the plain films twice. The interval of measuring the Cobb angle of the same radiograph separately with the two techniques was one week and the X-ray film was chosen randomly. The lines drawn on the film were wiped immediately after the measurement. No lines were drawn in the new technique group. The Cobb angle measured on the physical and digital radiographs with the new Cobb protractor was analyzed. To remove the deviation as a result of the determination of the endplate line, one more group with fixed endplate line was measured with the two techniques. Time of each measurement was recorded. The starting point was from fetching the protractor and pencil in the same position of the table and the end time was when the observer acquired the Cobb angle finally.

The transparent Cobb protractor consisted of two sliding shells in each ruler (Fig. 1). The black endplate marker was drawn in the middle of the sliding shell. When measuring, one endplate marker was aligned to one of the endplate lines and then aligned the other marker to the other endplate line of the curve by adjusting the position of the shell in the protractor (Fig. 2). The new Cobb protractor was able to measure the angle of each of two lines on the same plane without moving the two lines together indirectly. When both endplate markers aligned well, the Cobb angle could be read directly from the ruler. Each observer was trained to use the new tool.

Statistical analysis

Statistical analyses were performed using SPSS 13.0 software (SPSS Inc., Chicago, IL, USA). A paired *t* test was used to compare the time used for the measurement between

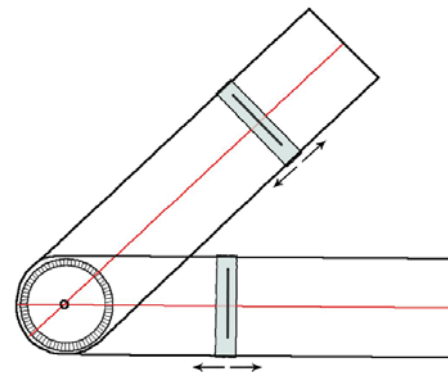


Figure 1. Diagram of the new Cobb protractor.

Each ruler of the protractor has a shell which could slide along the ruler. The black line in the middle of the sliding shell representing endplate marker is perpendicular to the red line.



Figure 2. Diagram of measuring process: align the two endplate markers to each of the endplates, and then read the Cobb angle from the protractor.

both techniques. The descriptive statistic of the two measurements for each observer was tabulated. The intraclass correlation coefficient (ICC) 2-way mixed model on absolute agreement was used to analyze the reliability of the two measurements. ICC value < 0.40 indicated poor reliability, 0.40-0.75 indicated fair to good reliability, and values > 0.75 reflected excellent reliability.⁴ Bland-Altman method as previously described⁵ was used to show the difference between the two techniques and the 95% confidence interval (CI) was calculated as $1.96 \times \text{standard deviation (SD)}$ where the SD was the SD of the intraobserver difference between the two techniques. The level of significance was set at $P=0.05$.

RESULTS

The mean time consumed for an observer to measure a Cobb angle was 26.0 ± 2.4 seconds for the standard method group, while it was 16.9 ± 2.6 seconds for the new tool group. The mean time for measuring a Cobb angle for the new tool group was significant shorter than that of the standard method group ($P < 0.05$).

The descriptive statistic of the two measurements for each observer is shown in Table 1. The overall mean standard angle for the major curve was 47.8° (ranged 31° - 86°).

Table 1. Descriptive statistic of the two measurements for each observer (degrees)

Observers	Techniques	Mean Cobb angle	Standard deviation of absolute difference between two measurements	Mean absolute difference between two measurements	95% confidence interval for the absolute difference ($\pm$) between two measurements
Observer 1	Standard method	48.0	1.51	2.25	4.41
	New technique	47.5	1.34	1.92	3.76
Observer 2	Standard method	48.1	2.06	2.87	5.63
	New technique	47.2	1.58	2.63	5.15
Observer 3	Standard method	47.5	2.27	3.10	6.08
	New technique	48.4	1.47	2.07	4.06
Overall	Standard method	47.8	1.98	2.74	5.37
	New technique	47.7	1.48	2.20	4.31

Both of the intraobserver and interobserver ICCs were over 0.9 for all observers by both two methods. The mean overall intraobserver ICC was 0.971 (0.949-0.986) and the mean interobserver ICC was 0.971 (0.945-0.987) for the standard method group, while the overall intraobserver ICC was 0.985 (0.973-0.993) and the interobserver ICC was 0.979 (0.960-0.990) for the new tool group. When the endplate lines were fixed in the films, the intraobserver ICC for the standard method group was 0.995 (0.988-0.998) and it was 0.998 (0.996-0.999) for the new tool group. The SD of absolute difference and the 95% CI between 2 measurements were 1.130° and $\pm 1.837^\circ$ respectively in the standard method group, while they were 0.712° and $\pm 0.993^\circ$ in the new tool group.

Bland-Altman scatter plot graph (Fig. 3) shows the signed measurement difference versus mean Cobb angle between the pairs of standard method and new technique measurements for the same radiograph. The mean signed difference of the two methods was 0.16° which was not significantly different from zero ($P=0.788$). The SD of the

difference was 3.0° . The 95% CI was ranged from -5.7° to 6.0° . Figure 4 provides a visual representation of the agreement of each standard angle measurement among observers by the two techniques (standard method versus new technique).

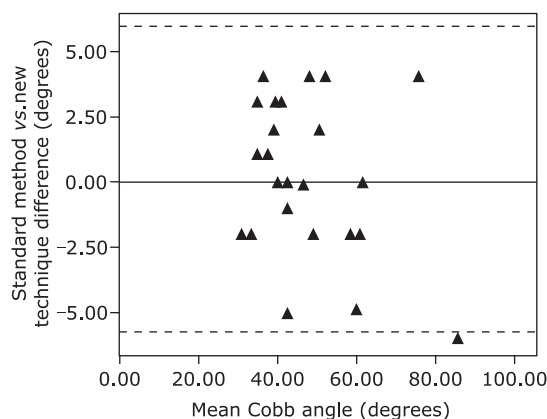


Figure 3. Scatter plot graph of signed measurement different between pairs of standard method and the new technique for the same radiograph.

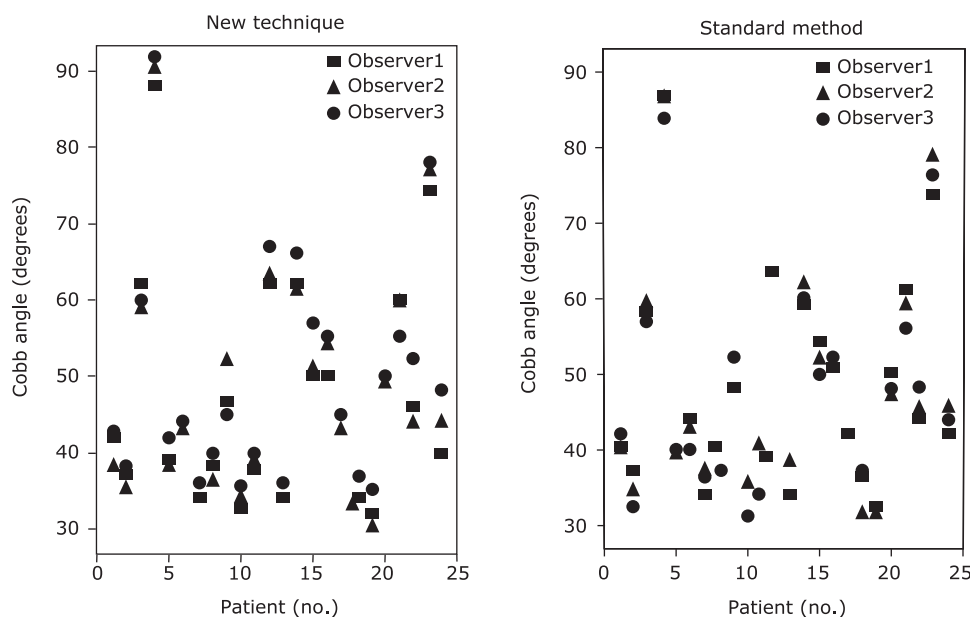


Figure 4. Interobserver variability of the two methods.

DISCUSSION

Cobb angle is an important radiography parameter which determines the severity of scoliosis. Most authors defined progression of scoliosis as an increase of 5 degrees or more measured by the Cobb measurement over two or more visits. Thus accurate measurement of the Cobb angle was of great importance.⁶ Cobb method as a standard Cobb measuring method had disadvantages: it needed to draw 4 lines in the films before measuring with a protractor; diameter of the pencil could be a source of error;⁷ it was time-consuming;⁸ more tools were required simultaneously to finish a measurement.

With the development of radiography, digitalized radiography is gradually replacing the conventional radiography in many medical center.² Measuring the Cobb angle as a routine job of an orthopaedic surgeon would become a problem when the radiograph was displayed on the computer screen. Although modern Picture Archiving and Communication Systems (PACS) including software could measure the Cobb angle quickly from the computer screen,^{9, 10} not all medical center had the advanced system and it could not measure Cobb angle on the hard copy films directly. Both of the Smartphone software and Oxford Cobbometer were previously reported as tools to calculate the angle without drawing lines and proved to be reliable and convenient.^{3, 8, 11} However, both of the measuring methods were relied on gravity. Whether incline of computer screen and radiography toward the horizontal plane would influence the measuring result was not demonstrated.

An ideal Cobb protractor should meet certain criteria: it should be simple to use and portable; it could measure the

angle directly from all forms of radiographs without drawing lines; its precision should not be influenced by the position of the radiographs; the protractor should have a better cost-benefit ratio;¹² most importantly, it should be better than or at least equivalent to the standard Cobb method in reliability.¹² The novel Cobb protractor met the first three criteria. However before widespread adoption of the new tool, its reliability should be analyzed as compared to the standard Cobb method.

The result of this study showed that both of the interobserver and intraobserver ICCs were excellent in the two methods. All ICC values were over 0.9 which agreed with the value (range 0.83-0.99) reported previously,^{13, 14} and all ICC values in the new technique group were slightly better than those measured by the standard Cobb method. Morrissey *et al*⁷ studied the intrinsic error in manual measurement and revealed that the type of protractor and marking pencil would also be the source of error. In our study, each observer was required to use the same protractor and pencil to eliminate it as a source of error. However the average absolute difference of two measurements in the standard Cobb method group was still higher than that in the new technique group for 0.5 degree. The source of error would probably originate from drawing vertical line and measurement of the angle with a protractor, while measurement with the new tool did not have such error.

It was widely accepted that the most significant source of error in measurement was the selection of different endplates.^{7, 15} Results of our study revealed that 95% CI for absolute difference between two measurements would decrease from 4.31° to 0.99° when the endplate lines were fixed, and it agreed with the result of previous research.⁹

To compare the difference of the measurement method itself, the error of different endplates selection was controlled by fixing the endplate lines in the radiography films. Although both of the ICCs showed improvement for the standard Cobb method and the new tool method when the endplate lines was fixed, 95% *CI* of the new tool method group was 45% smaller than that of the standard Cobb method group.

As a new measuring technique, time-consuming was another parameter that needed to be taken into consideration. Shaw *et al*⁵ recorded the total time for the observer to finish 20 measurements with the iPhone and protractor respectively and concluded that the mean time taken to measure Cobb angle with the iPhone was 3 minutes faster than the time spent on measurement using the protractor. Qiao *et al*⁸ reported that the mean time consumed for a measurement was 13.7 seconds for the smartphone, while the time was 37.9 seconds for the manual method. In the current study the time for a measurement with the new tool was approximately 10 seconds less than the time with the standard Cobb method. Although the small speed advantage was not significant in measuring one angle, the efficiency would be obvious when hundreds of curves need to be measured for scientific research purpose or when the doctor needed to face many scoliosis patients in the outpatient department.

There were some limitations of this study. The precision of the new Cobb protractor was limited as the minimum scale was 1 degree. Further improvement of the new Cobb protractor would be equipped it with an electronic gauge that can display the angle directly on the screen to eliminate the reading error between observers. Another limitation was the range of Cobb angle measured in our study was from 31° to 86° which included most of the patients with scoliosis. Thus, whether apply the protractor to measure small angle in the radiograph such as the intervertebral angle was as reliable as the normal protractor could not be extrapolated.

In conclusion, the novel Cobb protractor was designed to measure Cobb angle for scoliosis patients without drawing line on the radiograph to bring convenient for the orthopedic surgeon. The reliability study demonstrated that the new measuring instruments had a higher ICC value than the standard Cobb method and it was more timesaving. The Cobb protractor could measure almost all forms of radiograph as it did not need to draw lines.

REFERENCES

1. Cobb J. Outline for the study of scoliosis. Instr Course Lect 1948; 5:261-75.
2. Gladnick BP, Schreiber JJ, Ishmael CR, et al. Assessment of vertebral curves using the Manual Post-It(R) Technique. J Spinal Disord Tech 2013; [Epub ahead of print].
3. Jacquot F, Charpentier A, Khelifi S, et al. Measuring the Cobb angle with the iPhone in kyphoses: A reliability study. Int Orthop 2012; 36:1655-60.
4. De Vriendt T, Clays E, et al. Reliability and validity of the Adolescent Stress Questionnaire in a sample of European adolescents—the HELENA study. BMC public health 2011; 11:717.
5. Shaw M, Adam CJ, Izatt MT, et al. Use of the iPhone for Cobb angle measurement in scoliosis. Eur Spine J 2012; 21:1062-8.
6. Weinstein SL, Ponseti IV. Curve progression in idiopathic scoliosis. J Bone Joint Surg Am 1983; 65:447-55.
7. Morrissy RT, Goldsmith GS, Hall EC, et al. Measurement of the Cobb angle on radiographs of patients who have scoliosis. Evaluation of intrinsic error. J Bone Joint Surg Am 1990; 72:320-7.
8. Qiao J, Liu Z, Xu L, et al. Reliability analysis of a smartphone-aided measurement method for the Cobb angle of scoliosis. J Spinal Disord Tech 2012; 25:E88-92.
9. Gstoettner M, Sekyra K, Walochnik N, et al. Inter- and intraobserver reliability assessment of the Cobb angle: Manual versus digital measurement tools. Eur Spine J 2007; 16:1587-92.
10. Zhang J, Lou E, Hill DL, et al. Computer-aided assessment of scoliosis on posteroanterior radiographs. Med Biol Eng Comput 2010;48:185-95.
11. Rosenfeldt MP, Harding IJ, Hauptfleisch JT, et al. A comparison of traditional protractor versus Oxford Cobbometer radiographic measurement: Intraobserver measurement variability for Cobb angles. Spine 2005; 30:440-3.
12. Langensiepen S, Semler O, Sobottke R, et al. Measuring procedures to determine the Cobb angle in idiopathic scoliosis: A systematic review. Eur Spine J 2013; 22: 2360-71.
13. Tanure MC, Pinheiro AP, Oliveira AS. Reliability assessment of Cobb angle measurements using manual and digital methods. Spine J 2010; 10:769-74.
14. Allen S, Parent E, Khorasani M, et al. Validity and reliability of active shape models for the estimation of Cobb angle in patients with adolescent idiopathic scoliosis. J Digital Imaging 2008; 21:208-18.
15. Oda M, Rauh S, Gregory PB, et al. The significance of roentgenographic measurement in scoliosis. J Pediatr Orthop 1982; 2:378-82.