



Reliability of 2 Smartphone Applications for Cobb Angle Measurement in Scoliosis

İsmail Emre Ketenci, MD, Hakan Serhat Yanık, MD,
Özgür Erdoğan, MD, Levent Adıyeke, MD, Şevki Erdem, MD

Department of Orthopedics and Traumatology, Haydarpasa Numune Education and Research Hospital, Istanbul, Turkey

Background: As mobile technology has evolved, smartphone applications have been used for radiographic angle measurements in daily clinical practice. This study aimed to assess the reliability of 2 smartphone applications (iPinPoint and Cobbmeter) in measuring scoliosis Cobb angles compared with picture archiving and communication system (PACS) tools.

Methods: Anteroposterior whole spinal digital radiographs of 50 patients were retrospectively analyzed. Four observers measured Cobb angles of predetermined major structural curves using the tools in the PACS software and 2 smartphone applications. The inter- and intraobserver reliability were measured using intraclass correlation coefficients (ICC).

Results: Very good interobserver agreement was seen with PACS, iPinPoint, and Cobbmeter measurements (ICC, 0.991, 0.980, and 0.991, respectively). Intraobserver reliability of the 4 observers was also very good for all techniques (ICC > 0.9 for all observers).

Conclusions: Both smartphone applications were reliable in measuring scoliosis Cobb angles, with reference to PACS tools. They may be useful when digital or manual measurement tools are not available.

Keywords: *Scoliosis, Smartphone, Software, Measures*

Cobb angle measurement is important for evaluating curve severity and progression, as well as for determining treatment strategies in adolescent idiopathic scoliosis (AIS).¹⁾ Several measurement methods have been used on plain and digital radiographs, such as manual goniometer and computer-aided techniques. With the improvement of picture archiving and communication system (PACS), digital radiographs have been used more widely. Good correlation to manual measurements and improved measurement precision have been shown for digital Cobb angle measurements.^{2,3)}

After the integration of mobile technology into daily clinical practice, smartphone applications have been used for radiographic angle measurements. Their simplicity and

portability enable practical use and save time in clinical practice. Reliability of these applications has been assessed for Cobb angle measurement in scoliosis and kyphosis, as well as hallux valgus angle measurement.⁴⁻⁸⁾ In this study, we aimed to assess the reliability of PACS measurement tools and 2 smartphone applications in measuring Cobb angles. Our hypothesis was that smartphone measurement has comparable reliability to PACS measurement, which has been shown to be a reliable technique.

METHODS

Radiographic Measurement

Anteroposterior digital whole spine radiographs of 50 patients with AIS were randomly extracted from our hospital's database. Selection criteria were age between 12 and 20 years, Cobb angle at least 30°, and having no prior spinal surgery. Exclusion criteria were diagnosis other than AIS and unclear images. A spinal surgeon (SE) who was not involved in measurement determined the upper and lower end vertebrae of the curves to be measured. For each

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Correspondence to: Levent Adıyeke, MD

Department of Orthopedics and Traumatology, Haydarpasa Numune Education and Research Hospital, 34668 Uskudar, Istanbul, Turkey

Tel: +90-216-542-32-32, Fax: +90-216-336-05-65

E-mail: leventadiyeke@gmail.com

patient, the largest structural curve was selected for measurement. Four blinded observers, 2 spinal surgeons (IEK, HSY) and 2 orthopedic surgeons (OE, LA), measured the Cobb angle of the determined curves, using the software in PACS of our institution and 2 smartphone applications. In order to assess the intraobserver variability, measurements were repeated on the same radiographs after 2 weeks in a different order, to minimize the recall of prior measurements.

The smartphone measurements were performed using an Apple iPhone model 6S (Apple Inc., Cupertino, CA, USA). The iPinPoint application was downloaded free, whereas the Cobbmeter application was bought from the Apple iTunes store. The iPinPoint version 2.1 (i-SmartSolutions, 2010–2017) is an application that uses the built-in camera of the smartphone for angular measurement. First, a photograph was taken, pointing straight to the monitor showing the radiograph. In order to minimize parallax errors, the smartphone was kept parallel to the monitor. The Cobb angle measurement tool within the application was used to measure the curve magnitude (Fig. 1). Cobbmeter, version 2.5 (2009–2014) is an accelerometer-based application, which calculates the Cobb angle by measuring the tilt angles of the end vertebrae (Fig. 2). While measuring the curve angles, the superior edge of the smartphone was aligned to the superior endplate of the upper and to the inferior endplate of the lower end vertebra.⁶⁾

Statistical Analysis

All statistical analyses were conducted using IBM SPSS ver. 21.0 (IBM Corp., Armonk, NY, USA). The interobserver and intraobserver reliability was estimated using

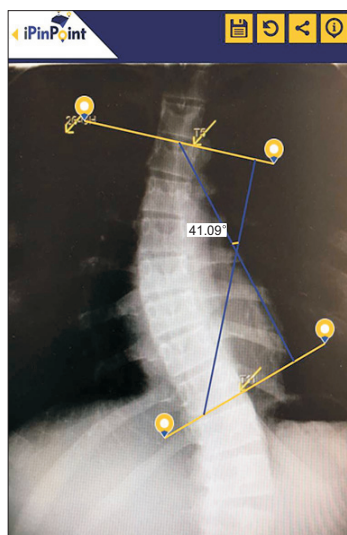


Fig. 1. Measurement with iPinPoint application.

intraclass correlation coefficients (ICCs) for the 4 observers. Poor reliability was considered present with values of 0 to 0.20, fair reliability with values of 0.21 to 0.40, moderate reliability with values of 0.41 to 0.60, good reliability with values of 0.61 to 0.80, and very good reliability with values of 0.81 to 1.0.⁹⁾ A *p*-value of < 0.05 was considered statistically significant.

RESULTS

Thirty-eight of the patients were women and 12 of them were men. The mean age of the patients was 15.4 years. Eighteen patients had Lenke type 1, 4 had type 2, 7 had type 3, 12 had type 5, and 9 had type 6 curves. The mean Cobb angle measurements of the 4 observers for each technique are given in Table 1.

ICCs for inter- and intraobserver reliability are given in Tables 2 and 3, respectively. Very good interobserver agreement was seen with all 3 methods. Intraobserver reliability was also very good for all techniques for all observers. ICCs for inter- and intraobserver reliability were significant at the 0.001 level.

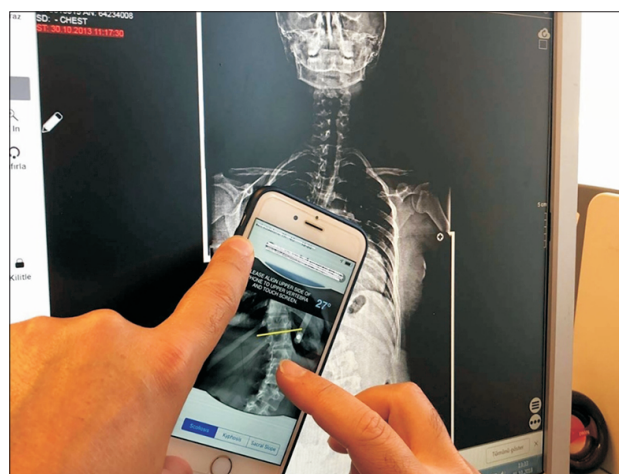


Fig. 2. Measurement with Cobbmeter application.

Table 1. Mean Cobb Angle Measurements of All Observers for Each Technique

Observer	PACS	iPinPoint	Cobbmeter
1	51.25 ± 12.52	51.76 ± 12.48	50.77 ± 12.49
2	51.53 ± 12.34	51.25 ± 12.24	51.07 ± 12.36
3	50.93 ± 12.51	51.47 ± 12.53	51.45 ± 12.55
4	50.49 ± 12.54	50.73 ± 12.71	50.65 ± 13.35

Values are presented as mean ± standard deviation. PACS: picture archiving and communication system.

Table 2. Interobserver Values

Variable	ICC (95% CI)	p-value
PACS	0.991 (0.984–0.996)	< 0.001
iPinPoint	0.980 (0.967–0.991)	< 0.001
Cobbmeter	0.991 (0.982–0.996)	< 0.001

ICC: intraclass correlation coefficient, CI: confidence interval, PACS: picture archiving and communication system.

DISCUSSION

Several techniques can be used to measure the Cobb angle in scoliosis in order to assess the curve magnitude and progression, which are important for diagnosis and treatment of the deformity. Since PACS became more available recently, the traditional goniometer technique has been replaced by digital measurement. The integration of mobile technology into daily life introduced smartphone applications to clinical practice for Cobb angle measurement, which can be performed both on a hard copy and digital image.

Since digital techniques enable modifications of brightness, contrast, and magnification of images, as well as precise adaptation of endplate lines, they enable more accurate measurements compared to goniometer techniques. Moreover, improved inter- and intraobserver agreement compared to manual measurements were found in some studies.^{2,3)} However, patients may present with hard copy radiographs or computer discs without angle measurement tools. In this case, angle measuring smartphone applications may represent a useful alternative to digital or manual measurement.

Several studies have been performed to assess the reliability of smartphone applications in measuring hallux valgus and Cobb angles, by comparing them with manual or digital measurements.⁴⁻⁸⁾ Shaw et al.⁴⁾ and Qiao et al.⁵⁾ compared goniometer and smartphone measurements of Cobb angles in scoliosis, and they found smartphone measurements were equivalent to manual measurements in terms of reliability and efficiency. Walter et al.⁷⁾ compared smartphone and PACS measurements of hallux valgus angles and found that smartphone applications were as reliable as PACS software. The applications used in these studies were accelerometer-based, which utilize the position sensor of the device. The iPinPoint application, which allows for measurements on photographs, was used for the first time in the study of Mattos E Dinato et al.⁸⁾ They found iPinPoint was more reliable than an accelerometer-based application in measuring hallux valgus angles with

Table 3. Intraobserver Values

Observer	ICC (95% CI)	p-value
Observer 1		
PACS	0.997 (0.994–0.998)	< 0.001
iPinPoint	0.992 (0.985–0.996)	< 0.001
Cobbmeter	0.994 (0.986–0.997)	< 0.001
Observer 2		
PACS	0.994 (0.986–0.997)	< 0.001
iPinPoint	0.982 (0.966–0.992)	< 0.001
Cobbmeter	0.996 (0.992–0.998)	< 0.001
Observer 3		
PACS	0.994 (0.986–0.997)	< 0.001
iPinPoint	0.974 (0.952–0.989)	< 0.001
Cobbmeter	0.987 (0.975–0.993)	< 0.001
Observer 4		
PACS	0.991 (0.979–0.996)	< 0.001
iPinPoint	0.983 (0.965–0.992)	< 0.001
Cobbmeter	0.992 (0.985–0.997)	< 0.001

ICC: intraclass correlation coefficient, CI: confidence interval, PACS: picture archiving and communication system.

reference to goniometer measurements. We did not demonstrate any differences between the accelerometer-based Cobbmeter and photograph-based iPinPoint applications in terms of inter- and intraobserver variability. We found them equivalent to PACS measurement, which is known to be a reliable technique. This result confirmed our hypothesis.

To the best of our knowledge, this is the first study in the literature to compare the 2 smartphone applications with different mechanisms in measuring scoliosis Cobb angles. Since endplate selection may cause intra- and interobserver variability, we predetermined the end vertebrae in order to obtain more uniform measurements. This enabled us to assess solely the measurement ability of the applications. There were also some limitations. If not used properly, both smartphone applications are prone to measurement errors. For iPinPoint measurements, the smartphone screen should be kept parallel to the computer screen while taking the photographs, in order to minimize parallax errors. For Cobbmeter measurements, it is important to properly align the superior edge of the smartphone with the endplates, which may be more difficult than digi-

tal or manual measurements. We also did not compare the time consumed for all 3 techniques. However, subjectively, measurements with all techniques were very fast, especially after the observers got used to the applications.

In conclusion, both smartphone applications can be used for measurement of scoliosis Cobb angles safely because they are as reliable and reproducible as PACS measurements. They are especially useful when hard copy

radiographs or digital images without measuring tools need to be assessed. They may eliminate the need to carry additional manual equipment for these occasions.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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