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A Comparison of Reliability in Measuring Spinal Curvature

Apichaya Kiertubonpaiboon[#1], Waranyu Wongseree[#2], Wimol San-Um[*3],
Adisorn Leelasantitham[#4] and Supaporn Kiattisin[#5]

[#]*Technology of Information System Management Program, Faculty of Engineering, Mahidol University*
25/25 Phuttamonthon 4 Road, Salaya, Nakhon Pathom 73170, Thailand
[1]apic5@hotmail.com
[2]waranyu1979@hotmail.com
[4]ladisorn@hotmail.com
[5]tom_kiattisin@hotmail.com

[*]*Intelligent Electronic Systems Research Laboratory, Faculty of Engineering, Thai-Nichi Institute of Technology*
Pattanakarn, Suanluang, Bangkok, 10250, Thailand
[3]wimol@tni.ac.th

Abstract— **The purpose in this study is to assess intra-rater and inter-rater reliability of 3 methods for measuring spinal curvature in 30 anteroposterior radiograph 2D view (AP view) with spinal patients of Lerdsin hospital during the year from 2004 to 2011. Three methods i.e. Cobb, Ferguson and Polynomial are compared with each value in terms of reliability. Ferguson is the traditional method and Cobb is probably the most popular, while polynomial is one of the first documented mathematical models for sagittal spinal curvature. Intraclass correlation coefficient (ICC) is used to calculate the inter-rater reliability (ICC model 2, 1) and intra-rater reliability (ICC model 3, 1). The statistical analysis shows that the intra-rater reliabilities of Ferguson, Cobb and Polynomial are 0.968, 0.950 and 0.910, respectively. In similarity, their inter-rater reliabilities are 0.477, 0.659 and 0.407 respectively. The results indicate that the most reliable measurement of spinal curvature is the Ferguson method. It can be used to assess the measurement with some cautions especially. And the most reliable measurement of spinal curvature is Cobb method, when using between examiners.**

Keywords— **Cobb Method; Ferguson Method; Polynomial Method; Intra class Correlation Coefficient (ICC); Anteroposterior radiograph 2D view (AP-View); Intra-rater reliability; Inter-rater reliability**

I. Introduction

Spine structure is strong, responsible for the protection of the spinal cord. It also served catch of the back muscles and connects to other important bones of the body. A general condition of spinal disease is crooked spine (Scoliosis) and age-related degeneration (Spondylosis). Scoliosis is a general condition of spinal disease and abnormal curvature of the spine. Spondylosis is an age-related degeneration. Scoliosis is a curvature deformity of spine in the left and the right. Further, it may be twisted or rotated out of the original spine line through some cases may be congenital disorders, or degeneration process, including crook spine (Kyphosis). The compression of cervical and high loaded tendons can cause back pain which is affected atrophy and destruction of tissues (e.g. [1], [2]). The Spondylosis usually appears in increasing age to be significantly associated with degenerative of spine. Scoliosis and Spondylosis prevalence rise with both sexes of any age and differences in symptom. The main factor of spinal pain and Spondylosis are gender, age, and body mass index (BMI). Generally, it can be found in elderly and elevated BMI patients [3]. Because an increase or decrease in the curvature of spine that may result with force on the vertebral column depending on the curve that supports to the entire body weight. The spinal curvature can crowd or compress the spinal structures and become a lumber pain in which there is a sideways curvature of the spine [1]. According to an X-ray treatment, the radiographic is essential to quantify the spinal deformity for an angular measurement. The reliability result can lead the way to a suitable case for treatment. The aim of this study is to evaluate the reliability of measurements spinal curvature.

II. Literature Review

The most commonly use 2 methods for spinal deformity determination. The invasive technique is a radiographic analysis such as Cobb's method, which has high accuracy of popular measurement.

The other one is non-invasive techniques, which measured using Flexicurve (e.g. [4], [5]). The radiographic measurement is performed in anteroposterior radiograph 2D view (AP-View) and lateral view. Each method is measured from front edge of the spine (Anterior) and back edge of the spine (Posterior) with position marker (Landmark point). A number of landmark points are 4, 6, 9 and 36 points. The lateral radiograph 2D view landmark points are 6, 9 and 36 points. In particular, 6 points for joints with spine not be osteophytes and 9 points for joints with spine be osteophytes [6]. Moreover, 36 points are increased more details of shape than 9 points [7]. The anteroposterior and lateral radiograph 2D view landmark points are 4 points for determine the spinal curvature from corner of the edge spine bones. Observer errors in measurement techniques are not possible to mark point exactly tangent. This may induce a measurement error.

An analysis technique of the reliability of measurement is intra class correlation coefficient (ICC) which is educated about the comparison of reliability of measurements in a spinal curvature from 2D. The Cobb method is the most accurate determined for intra and inters observer reliability measurement [8]. It was origin comparison of reliability of measuring spinal curvature in Thai people.

III. Materials and Methods

A. The research experimental design

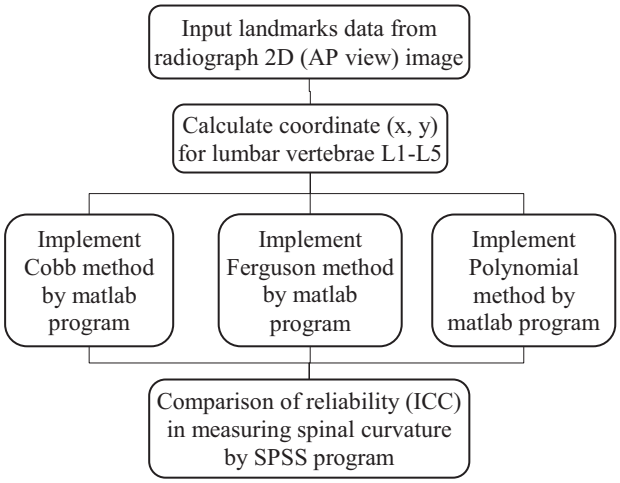

Fig. 1 Flow chart showing a comparison of reliability process for measurement spinal curvature

In this research, four distances transform-based, a comparison of reliability in measuring spinal curvature process as shown in Fig. 1. The first step of the process is input landmarks point in radiograph 2D (AP view) images. The second step of the process is calculating coordinate (x, y) of lumbar vertebrae (L1 - L5) from first step data. The third step of process is performing implement to Cobb, Ferguson, Polynomial methods, which three methods is measurements spinal curvature. The final step is to comparison of reliability in measuring spinal curvature using intra class correlation coefficient (ICC).

B. Study and data collection

Evaluation of anteroposterior radiograph 2D (AP-View) analysis exams which is difficult to define. For example, the photo of lumber vertebrae is unclear of the edge (L1 - L5) because it possible causes of errors in the measurement curvature of the spine from landmark point as shown in Fig. 2. The clearly image of lumber vertebrae (L1 - L5) may reduce in significant error in curve evaluation as shown in Fig. 3.

In this study is examined by 3 graduate students who trained for spine landmarks and the anteroposterior radiographic 2D with spinal patients of Lerdsin hospital. The 30 photos are sampled as the complete sharpness of the edge lumbar vertebrae (L1 - L5) during on year 2004 - 2011.

Fig. 2 Example of anteroposterior radiograph 2D (AP view) are unclearly image

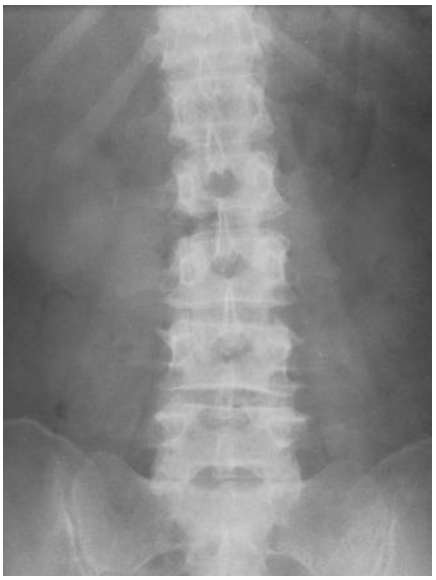

Fig. 3 Example of anteroposterior radiograph 2D (AP view) are clearly image

C. Landmark Point

Landmark points of a vertebra show the rim contours anteroposterior radiographic view. Posterior are two dorsal corners (Point 1 and 2). Anterior are two forepart corners (Point 3 and 4) as shown in Fig. 4.

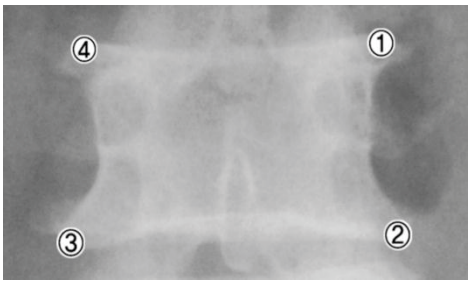

Fig. 4 Example of an image landmarks point

D. Measuring Spinal Curvature

The anposterior view is measured scoliosis deformity, which is showed in cross-section. The spinal curvature evaluation has been developing for anteroposterior view of radiographic image.

Ferguson and Cobb is the earliest methods. Both methods are variability and unreliability. The Cobb angle reflects changes in the end vertebrae inclination rather than changes within the spinal curvature. Scoliosis Research Society (SRS) as the standard method for quantification of scoliotic deformities was adopted in 1966, resulting in being nowadays the Cobb method still the most common method for the measuring spinal curvature.

1) Ferguson Method: The method evaluates the deformity by the angle between the two straight lines that connect the centers of the end vertebrae with the center of the apical vertebra. This method identified in geometrically using 12 points. An angle to be defined properly at the intersection of a and b as shown in Fig. 5.

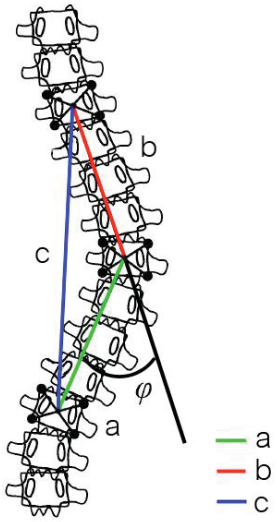

Fig. 5 Ferguson method [8], [9]

2) Cobb Method: The method evaluates the deformity by the angle between the two straight lines that are tangent to the superior and inferior endplate of the superior and inferior end vertebra, respectively. This method identified an angle drawing lines by 4 points as shown in Fig. 6.

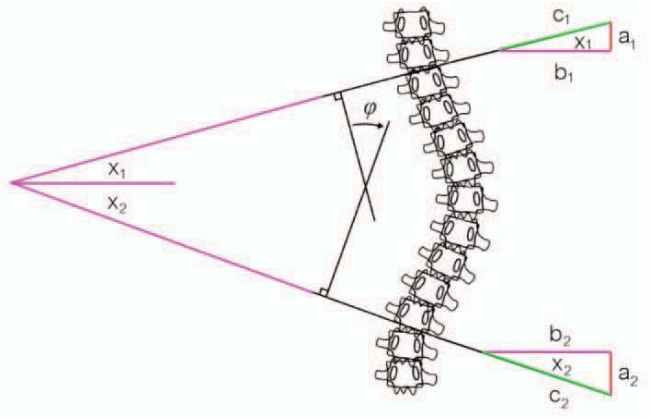

Fig. 6 Cobb method [8]

3) Polynomial Method: The method evaluates the deformity by divided the edge of the lumbar vertebrae (L1 - L5) and 4 point for every single spine bones. Thus, the coordinates of spines possible create a polynomial equation with regression analysis. In this category, the second order of polynomial equation is determined an angular of the upper to the lower of spine bones. This method should identify 20 points as shown in Fig. 7.

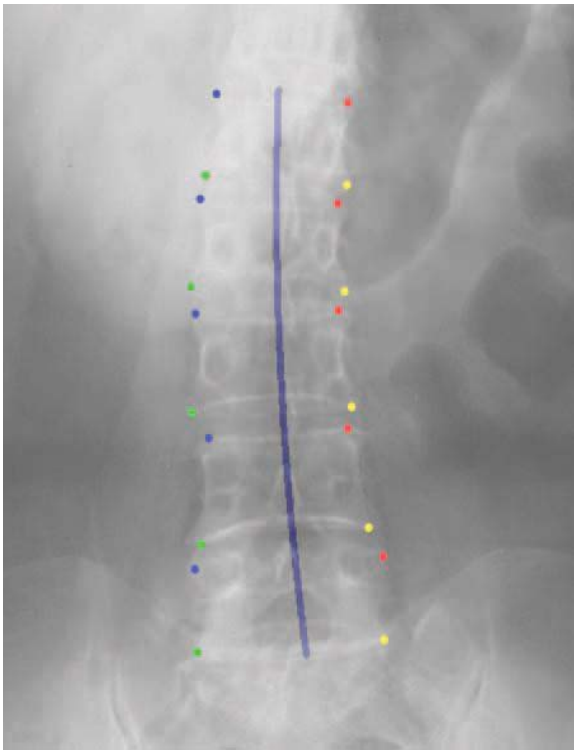

Fig. 7 Polynomial method

IV. Experimental Result

The comparisons of reliability in measurements spinal curvature from anteroposterior radiograph 2D view (AP-View) are studied on 30 images of spinal patients Lerdsin hospital by 3 intra-observers. The result of intra-rater two-way mixed single model with absolute agreement type ICC (3, 1) is accurately measure a curve using 3 times per 1 image for observer. And inter-rater model two-way random single measures in absolute agreement type ICC (2, 1) is accurately measure a curve using 1 times per 1 image for each individual.

The comparison of assess intra examiner reliability as measured by observer ICC (3, 1) vs observers ICC (2, 1) in absolute agreement type as shown in Table 1. And consistency type as shown in Table 2.

Ferguson method were considered of highest reliability when ICC (3, 1) = 0.969. On the other hand, the polynomial method were lowest reliability with ICC (3, 1) = 0.912. Turning to Cobb method, there was significantly reliability up to 0.644 in ICC (2, 1), whereas the polynomial method had less measure accurately ICC (2, 1) = 0.392 as shown in Table 1.

Ferguson method were considered of highest reliability when ICC (3, 1) = 0.968. On the other hand, the polynomial method were lowest reliability with ICC (3, 1) = 0.910. Turning to Cobb method, there was significantly reliability up to 0.659 in ICC (2, 1), whereas the polynomial method had less measure accurately ICC (2, 1) = 0.407 as shown in Table 2.

In both conclusions, the reliability of spinal curvature is measured by Ferguson method that is considered higher reliability more than Cobb and Polynomial method. The angle identified by the Cobb method show acceptable performance as observers more than Ferguson method and Polynomial method.

TABLE I
Shows Comparison The Intra-Rater ICC (3, 1) & Inter-Rater ICC (2, 1) Reliability In Absolute Agreement Type Of Measuring Spinal Curvature

Method	Absolute agreement		
	Ferguson	Cobb	Polynomial
ICC (3, 1) Intra	0.969	0.952	0.912
ICC (2, 1) Inter	0.481	0.644	0.392

TABLE II
Shows Comparison The Intra-Rater ICC (3, 1) & Inter-Rater ICC (2, 1) Reliability In Consistency Type Of Measuring Spinal Curvature

Method	Consistency		
	Ferguson	Cobb	Polynomial
ICC (3, 1) Intra	0.968	0.950	0.910
ICC (2, 1) Inter	0.477	0.659	0.407

V. Conclusions

This investigation illustrates the accuracy and consistency values have no significant difference value between Cobb and Ferguson method, with a level of substantially more than the polynomial method. The polynomial methods are globalization, which has 20 points for landmarks point of the lumbar vertebrae edge (L1-L5). Conversely, Cobb method and Ferguson are localization, which are measured on partial landmarks point of the lumbar vertebrae. There is processing of coordinate data points from the landmarks point of especially. Measuring spinal curvature of Ferguson method is processing on the lumbar spine top (L1) on the middle (L3) and bottom (L5). And measuring spinal curvature of Cobb method is processing on the lumbar spine top (L1) and bottom (L5) so the measuring spinal curvature is global makes angle of curvature less than local. But the advantage global can be used the classification of the spinal curvature from coefficients of the equation. And to improve polynomial methods to better measure may be adjusted to a local or spline may give results more similar of Cobb method.

Acknowledgment

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