CLINICAL ARTICLE

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Kyphotic Angle Measurement Accuracy for Vertebral Osteoporotic Compression Fracture; Reliable Method for Kyphotic Angle Measurement

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Objective : Having a reliable and reproducible measurement technique to measure the sagittal contour in vertebral fractures is paramount to clinical decision making. This study is designed to determine the most reliable measurement technique in osteoporotic vertebral compression fracture.

Methods : Fifteen lateral radiographs of thoracic and lumbar fractures were selected and measured on two separate occasions by three spine surgeons using six different measurement techniques (Centroid, Harrison Posterior Tangent Methods and 4 different types of modified Cobb method). The radiograph quality was assessed and the center beam location was determined. Statistical analysis including ANOVA for repeated measures was carried out using the SAS software (v 8.0)

Results : The inter and intraobserver variance of the Cobb method 4 and Harrison posterior tangent method were significantly lower than the other four methods. The intraobserver correlation coefficients were the most consistent using the Cobb method 4 (0.982), which was followed by the Harrison posterior tangent (0.953) and Cobb methods 1 (0.874). The intraobserver agreement (% of repeated measures within 5 degrees of the original measurement) ranged from 42% to 98% for each technique for all three observers, with the Cobb method 4 showing the best agreement (97.8%) followed by the Harrison posterior tangent method (93.7%).

Conclusion : The Cobb method-4 and Harrison posterior tangent methods, when applied to measuring the kyphosis, are reliable and have a similar small error range. The Cobb method 4 shows the best overall reliability. However, the centroid method and Cobb method using a fractured endplate do not produce an accurate result due to inter and intraobserver differences in determining the baseline.

KEY WORDS : Osteoporosis · Vertebral compression fracture · Kyphotic angle · Modified Cobb method · Harrison posterior tangential method · Centroid method.

Introduction

Osteoporosis is a major health issue for the elderly, and the incidence of vertebral compression fracture-related sequela is expected to increase as the general population ages. Therefore, osteoporosis compression fractures of the thoracolumbar vertebrae are becoming an increasing part of the practice of all spine surgeons[6,17,20].

Having a reliable and reproducible measurement technique is essential when making clinical decisions regarding the treatment of thoracolumbar spine deformities[4,15].

Because there are few reliability studies measuring the thoracolumbar kyphosis in an osteoporotic vertebral compression fracture[8], this study examined the reliability and clinical utility of kyphosis determination using six different radiographic methods. The six methods for the kyphotic angle measurements were compared statistically.

Materials and Methods

Fifteen lateral radiographs of the thoracic and lumbar osteoporotic vertebral compression fractures were selected and measured on two separate occasions by three spinal surgeons using the following six different measurement techniques

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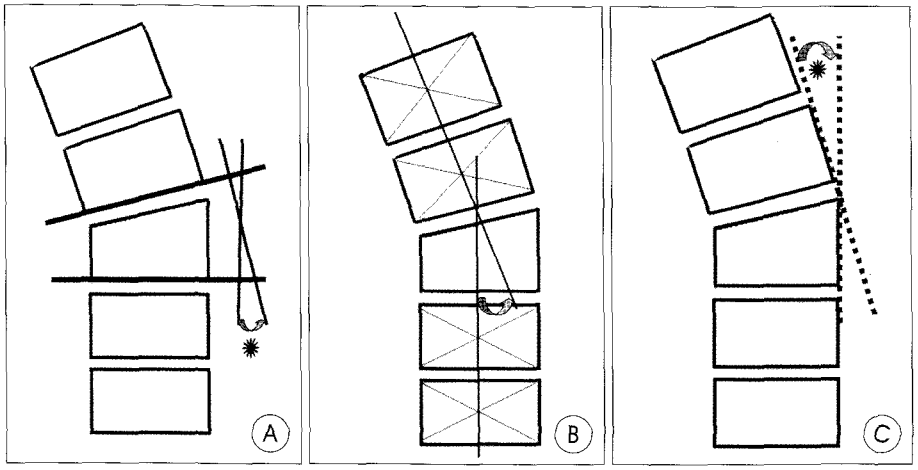

Fig. 1. Various methods for measuring the kyphotic angle, A : Modified Cobb method requires either the superior or inferior endplates of the vertebral body for kyphotic angle measurement. B : The centroidal angle is constructed in the lateral view by connecting the intersections of the vertebral body diagonals. This method uses all four vertebral body corners and requires four vertebral bodies to create the kyphotic angles. C : Two posterior vertebral body margins are used as baseline for Harrison posterior tangent method.

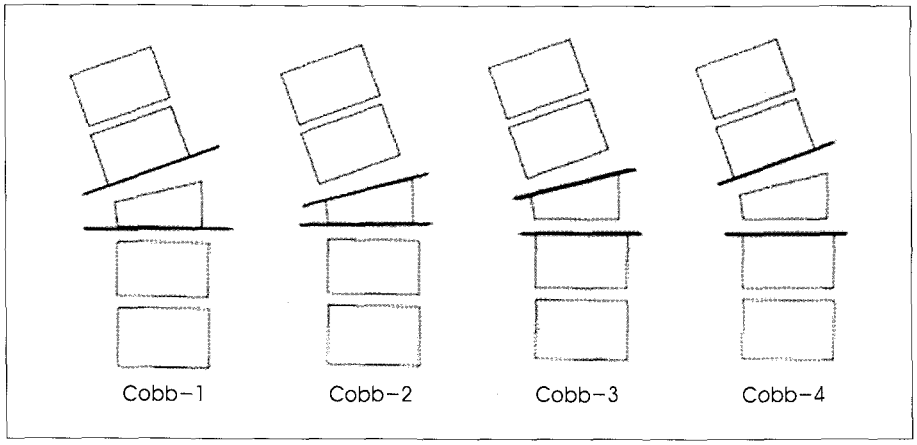

Fig. 2. Schematic diagrams showing the four different modified Cobb methods based on the endplate selection as the measuring line.

(Fig. 1, 2) : 1) The Centroid method, the centroidal angle was constructed in the lateral view by connecting the intersections of the vertebral body diagonals; 2) The Harrison posterior tangent(HPT) method, measuring the angle between the posterior vertebral body above and below the injured vertebra; 3) the modified Cobb method-1, measuring from the inferior endplate of the vertebral body one level above the injured vertebral body and the inferior endplate of the fractured body; 4) the modified Cobb method-2; measuring from the superior and the inferior endplate of the fractured body; 5) the modified Cobb method-3, measuring from the superior endplate of the injured vertebral body and the superior endplate of the vertebra below the injury; and 6) the modified Cobb method-4, measuring from the inferior endplate of the vertebra above the injury and the superior endplate of the vertebra below the injury. All observers were clinicians with 4 years, 9 years and 15 years of experiences in the field of neurosurgery. The observers were blinded to the dates on which the radiographs had been taken, the patients' identities, and any other measurements. The same type of protractor (United States Manufacturing, Pasadena, California) and pencil were used for all the angular determinations. After each measurement, the numbers were recorded and all the lines and marks were erased. Each observer measured the radiographs twice, with an interval of at least three weeks between measurements. Many investigators considered a measurement difference between successive radiographs of 5° to be clinically important[2,11]. Therefore, this value was used to estimate the intraobserver agreement of the successive measurement values. Statistical analysis of the data including ANOVA for the repeated measures was carried out using the SAS software (V 8.0). All the reliability estimates are presented with a 95% confidence interval. P values <0.05 were considered significant.

Results

Three independent observers measured 15 lateral radiographs of thoracolumbar (T7-L2) fractures on two separate occasions using six different measurement methods. Using the Denis classification of the compression fractures, there were 4 Type A fractures, 9 Type B fractures, and 2 Type C fractures. The inter and intraobserver variance of the Cobb method 4 and the HPT method were significantly less than other four methods ($P<0.05$, Table 1). The inter and intraobserver correlation coefficients (Table 2) were the most consistent for the Cobb method 4 (0.982), which was followed by the HPT method (0.953) and Cobb method 1 (0.874). The intraobserver agreement (% of repeated measurements within 5° of the initial measurement, Table 3) ranged from 42% to 98% for each technique for all three observers. Again, the most consistent results overall were obtained using the Cobb method 4 (97.8%) followed by the HPT method (93.3%). The centroid method and Cobb method 2 (measuring from the endplates of the injured vertebra) showed the least agreement.

Table 1. Summary statistics for six different measurement methods and remeasurements on each 15 radiographs by each of three examiners (Inter- & intraobserver variance)

Method	Mean (degree)	SD	Lower 95% CL for mean	Upper 95% CL for mean
Centroid	4.87	2.44	4.13	5.59
HPT	2.39	1.77	1.86	2.92
Cobb-1	3.54	2.15	2.05	3.04
Cobb-2	5.17	3.05	4.26	6.10
Cobb-3	4.50	2.40	3.78	5.22
Cobb-4	1.43	1.05	1.12	1.75

SD : standard deviation, CL : confidence limit, HPT : Harrison posterior tangent method

Table 2. Correlation coefficient of the six different measurement techniques for inter- & intraobserver reliability

Method	Coefficient
Cobb-4	0.98 (0.94-0.99)
Harrison posterior tangent	0.95 (0.91-0.97)
Cobb-1	0.87 (0.81-0.90)
Cobb-3	0.84 (0.79-0.89)
Centroid	0.81 (0.73-0.84)
Cobb-2	0.71 (0.65-0.76)

Table 3. Intraobserver agreement (probability that the same observer would measure the same radiograph within 5 degree of the initial measurement, %)

Method	Agreement (%)
Cobb-4	97.8
Harrison posterior tangent	93.3
Cobb-1	76.7
Cobb-3	57.8
Centroid	44.4
Cobb-2	42.2

The Cobb method-4, and the HPT methods were found to be reliable when applied to kyphosis measurements and had a similar small error range. Moreover, the Cobb method 4 showed the best overall intraobserver and interobserver reliability. The centroid method did not provide an accurate segmental analysis, used more points and required more time, and resulted in a smaller angle of total kyphosis than either the Cobb or HPW methods. However, the Cobb methods using a fractured endplate did not provide an accurate result because of the larger inter and intraobserver difference in determining the baseline.

Discussion

Vertebral compression fractures(VCF) are common in the elderly and occur when the vertebra is too weak to support the loads associated with everyday activities or trauma[7,13,14].

The resulting increased thoracolumbar kyphosis is believed to be associated with a myriad of clinical syndromes regardless of whether they are acutely painful[1].

These include the psychological distress caused by the following cosmetic appearances : an accentuated cervical lordosis, an impaired rib-cage expansion in breathing, an altered shoulder alignment and a predisposition to a glenohumeral pathology, early osteoarthritis and disc degeneration, malnutrition caused by early satiety and severe chronic back pain[19,20].

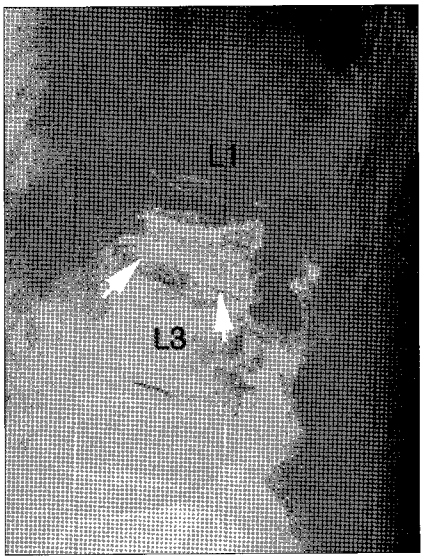

Fig. 3. An example lateral radiograph of an osteoporotic vertebral compression fracture shows radiolucency of the vertebra and an irregularity of the fractured endplate (arrows) in which it is difficult to place uniform landmarks on the film to measure the kyphotic angle.

The treatment for thoracic and lumbar compression fractures is based on the degree of resultant kyphosis and height loss. Therefore, radiographs need to provide adequate information regarding the deformity in order to understand the mechanisms for its progression in kyphosis or scoliosis and to make an adequate therapeutic decision[2,9].

Although method for measuring the extent of height loss is uniform[10], various clinical methods have been used to measure the sagittal contour in these VCFs and there are few controlled trials comparing the results[8].

The Cobb angle is the most widely used parameter for quantifying the severity of deformity curvatures[15]. The Cobb method was originally drawn on anteroposterior(AP) radiographs for evaluating scoliosis, in which endplates are used as the baseline[18]. If the endplates cannot be easily seen as a result of a metastasis, infection, or osteoporosis, a baseline can be drawn along the top or bottom of the pedicles. The capability of the base-line modification is the main reason for why the Cobb method is reliable for measuring measure scoliosis.

However, there are many criticisms of using the Cobb method for evaluating kyphotic deformities, such as difficulties in selecting the endplate as a baseline for the kyphosis measurement compared with scoliosis (Fig. 3), the extra possible human error in the four lines required using the traditional Cobb method, and the high interobserver and intraobserver error (5~10°)[4]. Because the Cobb angles were originally drawn on the anteroposterior radiographs, the use of endplate lines to construct the angles on the lateral radiographs are often referred to as the "modified Cobb method." These high measurement errors have also been reported when using the modified Cobb met-

hod for measuring the sagittal curves on the lateral lumbar views[1,2]. For the above reasons, several authors have included a segmental analysis or other radiographic measurement methods on the lateral radiographs, such as the HPT method and the vertebral centroid methods[5,16].

However, the centroid method requires too many lines and dots to connect the intersections of the vertebral diagonals, which can be a source of measurement error, resulting in smaller angle measurements than the Cobb and posterior tangent methods. It is difficult to draw a baseline in the thoracic spine when using the Harrison posterior tangential line as a kyphosis measuring method due to blurring as a result of aeration of the lung field[4]. Moreover, there are few reliability studies measuring the thoracic kyphosis of osteoporotic vertebral compression fractures. Therefore, this study investigated the reliability and clinical utility of kyphosis determination using six different radiographic methods.

There is wide variability in the numerical results of a vertebral kyphosis restoration when different reporting methods are used. Each of these methods has been used for vertebral kyphosis reductions and there is no agreed method for reporting the vertebral kyphotic angle in the osteoporotic VCFs undergoing vertebroplasty or kyphoplasty[8]. Substantial variability in the reported magnitude of identical kyphosis reductions demonstrates the need for a uniform method for measuring, reporting, and interpreting this outcome.

In our analysis, six different methods were investigated and the Cobb method 4 and HPT method had the best overall intraobserver and interobserver reliability. This suggests that a fractured endplate should not be selected as a baseline for the Cobb method.

This study had important limitations. There was a small sample size and each measurement was carried out manually using conventional radiographs. The availability of digital radiographical images is increasing. One of the key benefits of digital imaging is the ability to alter the image parameters after exposure. The ability to alter the brightness, contrast and zoom factors dynamically at a workstation is a great advantage, which allows adjustments to be made to improve the image quality. In addition, a digital image can be stored, retrieved, and transmitted easily by electronic systems. Another important advantage of digital radiographs is that the stored images can easily be retrieved for study purposes as well as for interactions with other clinics[3].

Conclusion

In conclusion, angle measurement methods that do not use a fractured endplate yielded the most reliable results. Therefore, future clinical studies, particularly multicenter studies where different examiners will be measuring the kyphotic angle of osteoporotic compression fractures, can use either the Cobb method 4 or HPT method to reduce the intrinsic measurement error and variance.

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