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Reliability Analyses of Radiographic Measures of Vertebral Body Height Loss in Thoracolumbar Burst Fractures

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■ OBJECTIVE: **In thoracolumbar (TL) burst fractures, vertebral body height loss (VBHL) indicates the degree of instability and constitutes one of the decision criteria for surgical treatment. However, the relative reliability and variability of different measurement techniques for VBHL are unknown. We compared the reliability of different methods used to assess VBHL.**

■ METHODS: **A total of 144 patients with TL burst fractures were included, and lateral radiographs were taken twice at an interval of 2 weeks, which were examined by 3 observers. The measurement methods used included the anterior/posterior vertebral body height compression ratio (APCR), anterior height compression percentage (AHCP), and anterior/posterior vertebral body height compression ratio percentage. To compare the accuracy of measurements according to vertebral degeneration, subjects were divided into 2 groups based on the median age of 50 years.**

■ RESULTS: **In intraobserver comparisons, the APCR method showed a higher inter- and intraclass correlation coefficient (ICC) (>0.714) compared with the other methods. In interobserver comparisons, the ICC of the APCR (>0.793) was excellent. In intraobserver comparisons of the aged >50-years group, only the APCR method showed an excellent ICC (>0.753), whereas the AHCP method showed a fair to good ICC, and the anterior/posterior vertebral body height compression ratio percentage method had the lowest ICC. In interobserver comparisons of the aged >50-years group, the APCR and AHCP methods showed excellent ICCs. In the aged ≤50-years group, all 3 methods showed similar fair to good ICC values.**

■ CONCLUSIONS: **Based on comparative reliability analyses, we recommend the APCR method as the first-line technique and the AHCP as an alternative technique for measuring VBHL in TL burst fractures.**

INTRODUCTION

In thoracolumbar (TL) burst fractures, vertebral body height loss (VBHL) and the kyphosis angle indicate the degree of instability of spinal alignment and progression of the kyphotic deformity.[1-4] Although VBHL is not typically a critical factor in various classification and treatment algorithms based on radiographic characterization, increased VBHL may contribute to and enhance this instability, which can result in changes in the treatment plan.[5-10] Specifically, a VBHL >50% has been accepted as one of the standard characteristics of unstable fractures, with conservative treatment likely to fail and recommendation of surgical treatment.[1,11] The level of anterior vertebral body compression is significantly correlated with kyphotic deformity in the TL

Key words
- Burst fracture
- Compression ratio
- Measurement
- Reliability
- Vertebral body height loss

Abbreviations and Acronyms
AHCP: Anterior vertebral body height compression percentage
APCR: Anterior/posterior vertebral body height compression ratio
APCRP: Anterior/posterior vertebral body height compression ratio percentage
AVBH: Anterior vertebral body height
CI: Confidence interval
CT: Computed tomography
ICC: Inter- and intraclass correlation coefficient
MRI: Magnetic resonance imaging
PVBH: Posterior vertebral body height
TL: Thoracolumbar
VBHL: Vertebral body height loss

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spine.[12-15] In addition, from a socioeconomic perspective, VBHL is used as one of the most fundamental indicators of the degree of deformity due to spinal injury, as well as for the judgment of its sequelae in relation to various insurance and disability decisions, which are recently increasing. Therefore, accurately assessing the magnitude of VBHL is crucial to decide when surgery is necessary and appropriate.[1,5,8,11,13,16-19] A reliable measurement of VBHL is also essential for evaluating deformity progression in patients with non-operative management.[1,13]

Different measurement techniques on plain radiograph have been described to assess VBHL or vertebral body compression.[1,8,20-22] The first study exploring the measurement techniques preferred by a worldwide sample of spine trauma experts, including 107 surgeons from 43 different countries, found that the anterior/middle column vertebral body compression ratio was the most frequently used technique.[21] By contrast, the Spine Trauma Study Group recommended the routine use of the anterior vertebral body compression percentage to assess VBHL, based on the results of a systematic literature review.[20] These conflicting data were presumed to be owing to variability among the different measurement methods. The use of different or unreliable measurement techniques could result in different treatment plans leading to outcome variability for certain types of spinal fractures.

Therefore, it is important to minimize variability and improve the accuracy of measurement techniques using a standard methodology. However, to the best of our knowledge, it is unclear which specific measurement technique or combination of techniques will provide better reliability and less variability when measuring VBHL.[21] Therefore, we compared the reproducibility and reliability of a variety of VBHL measurement techniques in TL burst fractures.

METHODS

This retrospective study protocol was approved by the institutional review board (institutional review board no. 2017-07-033).

Subjects

A total of 144 consecutive patients (82 men and 62 women) with TL burst fractures (T11, T12, L1, and L2) who had a posterior instrumented fusion between 2004 and 2014 were included in this study. Burst fractures were confirmed by computed tomography (CT) and magnetic resonance imaging (MRI). The mean age was 49.2 years (range, 19–79 years) and the involved levels were T11 in 6 patients, T12 in 40 patients, L1 in 66 patients, and L2 in 32 patients.

Radiographic Measurements

TL spine lateral radiographs were taken at a standard tube-film distance of 180 cm, with the central ray targeting the T12–L1 vertebra in the left lateral decubitus position. Typical exposure factors were 250 mAs and 82 kVp. TL spine lateral radiographs without identifying information were submitted in random order to each of the 3 observers who were orthopedic spine surgeons with 11, 7, and 3 years of experience, respectively. We tested several radiographs prior to the real measurement to minimize observer bias. Each observer measured the 144 radiographs twice at an interval of 2 weeks to minimize memory effects. Using the 3 different radiographic methods, 2592 heights were generated. All measurements were performed using computer-based digital radiographs on a picture achieving computer system (DEIT-VIEW for Centricity 3.0, General Electric Medical Systems, Milwaukee, Wisconsin, USA).

The 2 most common methods and one new combination method were used to measure VBHL (Figure 1).

Method 1. Anterior/posterior vertebral body height compression ratio (APCR)[1,21]: The APCR is the ratio of the anterior vertebral body height (AVBH) to the posterior vertebral body height (PVBH), with the formula APCR = AVBH/PVBH.

Method 2. Anterior vertebral body height compression percentage (AHCP)[1,21]: The AHCP is the percentage of the anterior body height compression of the fractured vertebra ($AVBH_{V_2}$) divided by the mean anterior heights of the adjacent caudal ($AVBH_{V_1}$) and cranial ($AVBH_{V_3}$) vertebral bodies, with the formula $AHCP = AVBH_{V_2}/[(AVBH_{V_1} + AVBH_{V_3})/2] \times 100$.

Method 3. Anterior/posterior vertebral body height compression ratio percentage (APCRP): The APCRP is the percentage of the anterior/posterior vertebral body height compression ratio ($APCR_{V_2}$) of the fractured vertebra divided by the mean APCR of the adjacent caudal ($APCR_{V_1}$) and cranial ($APCR_{V_3}$) vertebral bodies, with the formula $APCRP = APCR_{V_2}/[(APCR_{V_1} + APCR_{V_3})/2] \times 100$.

To compare measurement accuracy according to degenerative spinal changes, subjects were divided into 2 groups based on the median age of 50 years as follows: 72 patients aged ≤50 years (<50 years) and 72 patients aged >50 years (>50 years).

Statistical Analyses

All statistical analyses were performed based on the assumption that observers were a random rather than a fixed factor. The inter- and intraobserver reliabilities of the 2 sets of measurements from the 3 observers were calculated using inter- and intraclass correlation coefficients (ICC) with 95% confidence intervals (CIs). The SPSS software version 21.0 (SPSS Inc., Richmond, California, USA) was used in all analyses, and ICCs were evaluated according to the Shrout and Fleiss's classification as follows: poor, <0.4; fair to good, 0.4–0.75; and excellent, >0.75.[23,24]

RESULTS

Reliability Analyses of all Radiographs

Tables 1 and 2 list the overall means, standard deviations, ICCs, and 95% CIs of all outcome measurements for the APCR, AHCP, and APCRP methods by the 3 observers using 144 radiographs. In intraobserver comparisons, the APCR method showed a higher ICC (>0.714) than the other 2 methods (AHCP >0.571, APCRP >0.564). The AHCP and APCRP methods were comparable. Similar results were found for interobserver comparisons; the ICC of the APCR method (>0.793) was excellent and the ICCs of the other 2 methods were fair to good. However, unlike the intraobserver comparison, AHCP had a higher ICC (>0.727) than APCRP (>0.576). Overall, the APCR method showed the highest reliability among the 3 methods

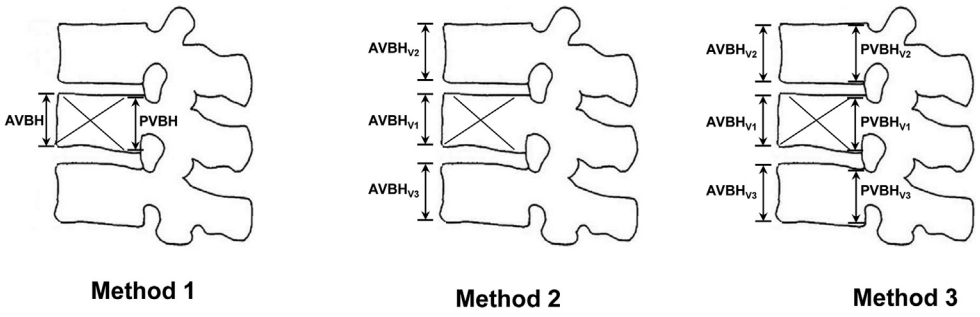

Figure 1. Three measurement techniques for assessing vertebral body height loss. Method 1, anterior/posterior vertebral body height compression ratio = AVBH/PVBH; Method 2 anterior vertebral body height compression percentage = $AVBH_{V1}/[(AVBH_{V2} + AVBH_{V3})/2] \times 100\%$; Method 3 anterior/posterior vertebral body height compression ratio percentage = $AVBH_{V1}/PVBH_{V1}/[(AVBH_{V2}/PVBH_{V2} + AVBH_{V3}/PVBH_{V3})/2] \times 100\%$. AVBH, anterior vertebral body height; PVBH, posterior vertebral body height.

when comparing intra- and interobserver ICCs. The AHCP method showed comparable or higher reliability compared to the APCRP method (Table 2).

Subgroup Reliability Analyses according to Age

Tables 3 and 4 summarize the overall means, standard deviations, ICCs, and 95% CIs to determine the reliability of the radiographs subdivided by the median age of 50 years. In intraobserver comparisons of the aged >50 year group, only the APCR method showed an excellent ICC (>0.753). The AHCP showed a fair to good ICC (>0.582), and the ICC of APCRP was the lowest (>0.426). Meanwhile, in the aged <50 year group, all 3 methods showed similar results, with fair to good reliability (ICC, APCR >0.689, AHCP >0.658, APCRP >0.739). It should be noted that the lowest ICCs of the 3 methods in the aged >50 year group ranged widely from 0.426–0.753. On the contrary, the lowest ICCs of the methods in the aged <50 year group were all >0.65, with a narrow range of 0.658–0.739 (Table 3).

In interobserver comparisons of the aged >50 year group, the APCR and AHCP methods showed excellent ICCs (>0.783 and >0.901, respectively). The ICC of method APCRP was the lowest (>0.732). As mentioned previously with respect to intraobserver agreement, all 3 methods in the aged <50 year group showed fair to good reliability with similar ICCs >0.6 (ICCs, APCR >0.741, AHCP >0.617, APCRP >0.744). Overall, the APCR method consistently showed high ICCs (>0.689) regardless of age (Table 4) in both intra- and interobserver reliability comparisons of the radiographs subdivided by the median age of 50 years. Overall, the APCR method showed the highest reliability regardless of age, and AHCP was the second most reliable method. The trend for greater reliability of APCR method was higher in the aged >50 year group compared with the aged <50 year group, for which all 3 methods had similar ICCs.

DISCUSSION

The majority of classifications and treatment guidelines for TL burst fractures are based on radiographic measurements. Typically, these measurements make up the basis for communication in research and clinical settings, and for data collection and outcome assessment. They are subsequently included in research and evidence-based guidelines, and ultimately establish the knowledge required for more meaningful clinical decision-making, leading to better patient care.[20] However, unwanted variability and bias inevitably lead to differences within and between observers. There are many potential causes for differences in inter- and intraobserver measurements for TL burst fractures. For example, biologic variability includes duplication owing to the bony silhouette of multiple lower ribs obliquely crossing the TL junction, altered endplate architecture, unique sources of variability in trauma populations (unknown premorbid anatomy), or the degree of vertebral bone mineralization. Technical variability includes differences in the patient-fluoroscopy relationship (angle, distance) and inability to maintain constant positioning for radiographs due to such things as fracture site pain and inability to maintain the standing position. In addition, individual observers may also introduce technical sources of error. In the present study, we compared the reproducibility and reliability of different techniques that are commonly used in clinical trials for measuring the compressed anterior body height of fractured vertebrae. Surprisingly, although the variability of the Cobb method for vertebral body compression and TL kyphosis has been well studied, the same cannot be said for VBHL measurement.[21,25] Only a few reports that have assessed the reliability of the VBHL measurement method, which is commonly used worldwide, have been published. Reliability is the ability of a tool to be reproducible and internally consistent over time, and it is generally evaluated by comparing intra- and inter-observer ICCs using the kappa statistic.[26-31] In this study, plain radiographs were used instead of advanced radiographic assessments such as CT and MRI because the subjects were acute trauma patients. It is undeniable that a plain radiograph is the most fundamental imaging tool to predict fracture severity intuitively. Moreover, it yields the fastest results compared with more precise radiologic methods such as MRI or CT in spine patients, including acute trauma. CT requires additional time to perform the scan itself as well as for image reconstruction and obtaining follow-up results through repeated measurements is limited due

Table 1. Intraobserver Reliability in all 72 Radiographs

Observers and Measurement Methods	Mean ± SD	ICCs	95% CI
First observer			
APCR	0.601 ± 0.028	0.714*	0.542–0.821
AHCP	0.659 ± 0.031	0.571*	0.315–0.732
APCRP	0.819 ± 0.013	0.612	0.380–0.757
Second observer			
APCR	0.575 ± 0.015	0.913	0.860–0.945
AHCP	0.630 ± 0.016	0.912	0.859–0.945
APCRP	0.803 ± 0.007	0.889	0.823–0.931
Third observer			
APCR	0.570 ± 0.016	0.758	0.614–0.849
AHCP	0.633 ± 0.028	0.675	0.480–0.797
APCRP	0.802 ± 0.018	0.564*	0.303–0.727

SD, standard deviation; ICCs, inter- and intraclass correlation coefficients; CI, confidence interval; APCR, anterior/posterior vertebral body height compression ratio; AHCP, anterior vertebral body height compression percentage; APCRP, anterior/posterior vertebral body height compression ratio percentage.
*Lowest values of each measurement methods according to the different observers.

Table 2. Interobserver Reliability in all 72 Radiographs

Observers and Measurement Methods	Mean ± SD	ICCs	95% CI
First versus second observer			
APCR	0.593 ± 0.019	0.793*	0.668–0.870
AHCP	0.648 ± 0.021	0.727*	0.564–0.829
APCRP	0.806 ± 0.008	0.743	0.589–0.839
First versus third observer			
APCR	0.579 ± 0.024	0.803	0.670–0.871
AHCP	0.643 ± 0.022	0.746	0.594–0.841
APCRP	0.804 ± 0.008	0.764	0.623–0.853
Second versus third observer			
APCR	0.583 ± 0.014	0.861	0.778–0.913
AHCP	0.630 ± 0.015	0.874	0.798–0.921
APCRP	0.807 ± 0.019	0.576*	0.323–0.735
First versus second versus third observer			
APCR	0.589 ± 0.018	0.840	0.764–0.895
AHCP	0.641 ± 0.020	0.838	0.761–0.894
APCRP	0.803 ± 0.008	0.859	0.791–0.907

SD, standard deviation; ICCs, inter- and intraclass correlation coefficients; CI, confidence interval; APCR, anterior/posterior vertebral body height compression ratio; AHCP, anterior vertebral body height compression percentage; APCRP, anterior/posterior vertebral body height compression ratio percentage.
*Lowest values of each measurement methods according to the different observers.

to radiation hazards. The limitations of MRI include that it is a costly test, scanning is lengthier than for CT, and emergency scanning is often impossible. In addition, MRI scans are not available for patients with cardiac pacemakers.

The main difference between the 3 methods of measuring TL burst fractures, including APCR, AHCP, and APCRP, is the reference height used in the denominator in the measurement formulae. Each method has its strengths and limitations. First, the APCR method has the advantage of representing any kyphotic deformity because it uses the anterior to posterior height ratio, and it is the most frequently and widely used method in clinical practice.[21] It is a useful method to assess the structural integrity of the fractured vertebral body, specifically, that of the anterior and middle columns of the injured vertebra. However, in the case of severe middle column involvement, compressed posterior body height leads to a lower ratio, which may cause underestimation of anterior body height loss. In our study, the APCR method showed the greatest intra- and interobserver reliability among the 3 methods, even in subgroup analyses according to age. Second, the AHCP method uses the mean height of the adjacent cranial and caudal bodies as the premorbid vertebral body height or reference height. Theoretically, AHCP could represent the compressed anterior body, a main pathologic column in the TL burst fractures, compared with the intact adjacent structures. Based on the results of a systematic literature review, the Spine Trauma Study Group recommended the routine use of this method to assess VBHL.[20] When the AHCP exceeds 50%, this parameter is widely used as a determinant for surgical management in most TL burst fracture classifications and treatment guidelines because of its ability to predict complications in conservatively treated TL burst fractures.[1,16,32-34] In our study, the AHCP method showed fair reliability but was less reliable than the APCR method. Third, the APCRP method was a technique designed by the authors of this study based on the combination of the 2 aforementioned methods. We hypothesized that this method may maximize the advantages of the prior 2 methods. However, it showed the lowest comparative reliability, perhaps because of the need for numerous measurement values and increased complexity.

When reliability was assessed in relation to age, the differences in ICC ranges between the 3 methods were greater in the aged >50 year group compared with the aged <50 year group. In the aged >50 year group, APCR showed the greatest intraobserver reliability and AHCP showed the greatest interobserver reliability. However, the intraobserver variance of the AHCP method in the aged >50 year group (ICC 0.582–0.946) and the interobserver variance of the AHCP method in the aged <50 year group (ICC 0.617–0.837) indicated significantly higher variability and greater discrepancy than seen using the APCR method. These results are thought to stem from degenerative changes in adjacent cranial and caudal anterior bodies such as the anterior bony bridge, traction spur, marginal osteophyte, or distortion of the spinal column. When managing aging-related degenerative deformity at the anterior column, it is difficult to define the bony landmarks and to measure the anterior height precisely owing to the invisible contour (**Figure 2**). By contrast, the APCR method consistently showed fair reliability, with ICCs >0.65 regardless of age. Consequently, based on the overall ICCs and comparative results

Table 3. Intraobserver Reliability of Radiographs Subdivided by Median Age of 50 Years

	Aged <50 years (n = 36)			Aged ≥50 years (n = 36)		
Observers and Measurement Methods	**Mean ± SD**	**ICCs**	**95% CI**	**Mean ± SD**	**ICCs**	**95% CI**
First Observer						
APCR	0.593 ± 0.022	0.740	0.491–0.868	0.610 ± 0.034	0.753*	0.536–0.853
AHCP	0.652 ± 0.029	0.658*	0.462–0.724	0.665 ± 0.033	0.723	0.458–0.859
APCRP	0.813 ± 0.009	0.823	0.654–0.910	0.825 ± 0.016	0.512	0.343–0.751
Second observer						
APCR	0.570 ± 0.013	0.938	0.878–0.968	0.580 ± 0.018	0.894	0.792–0.946
AHCP	0.623 ± 0.014	0.866	0.737–0.932	0.637 ± 0.019	0.946	0.894–0.972
APCRP	0.800 ± 0.007	0.857	0.719–0.927	0.805 ± 0.007	0.921	0.845–0.960
Third observer						
APCR	0.558 ± 0.015	0.689*	0.390–0.841	0.582 ± 0.017	0.847	0.700–0.922
AHCP	0.616 ± 0.018	0.859	0.723–0.928	0.649 ± 0.038	0.582*	0.179–0.787
APCRP	0.792 ± 0.014	0.739*	0.507–0.872	0.813 ± 0.023	0.426*	0.125–0.707

SD, standard deviation; ICCs, inter- and intraclass correlation coefficients; CI, confidence interval; APCR, anterior/posterior vertebral body height compression ratio; AHCP, anterior vertebral body height compression percentage; APCRP, anterior/posterior vertebral body height compression ratio percentage.
*Lowest values of each measurement methods according to the different observers.

Table 4. Interobserver Reliability of Radiographs Subdivided by Median Age of 50 Years

	Aged <50 years (n = 36)			Aged ≥50 years (n = 36)		
Observers and Measurement Methods	**Mean ± SD**	**ICCs**	**95% CI**	**Mean ± SD**	**ICCs**	**95% CI**
First versus second observer						
APCR	0.594 ± 0.016	0.813	0.633–0.905	0.593 ± 0.023	0.783*	0.574–0.889
AHCP	0.653 ± 0.026	0.617*	0.249–0.805	0.643 ± 0.017	0.901*	0.807–0.950
APCRP	0.809 ± 0.008	0.774	0.556–0.885	0.804 ± 0.008	0.732*	0.474–0.863
First versus third observer						
APCR	0.598 ± 0.017	0.741*	0.492–0.868	0.586 ± 0.024	0.866	0.545–0.930
AHCP	0.655 ± 0.028	0.706	0.427–0.899	0.631 ± 0.017	0.934	0.870–0.966
APCRP	0.809 ± 0.009	0.744*	0.497–0.869	0.798 ± 0.007	0.799	0.606–0.897
Second versus third observer						
APCR	0.582 ± 0.012	0.857	0.720–0.927	0.583 ± 0.015	0.869	0.743–0.933
AHCP	0.624 ± 0.013	0.837	0.680–0.917	0.636 ± 0.018	0.905	0.813–0.951
APCRP	0.794 ± 0.006	0.896	0.797–0.947	0.801 ± 0.007	0.919	0.842–0.959
First versus second versus third observer						
APCR	0.591 ± 0.015	0.857	0.751–0.922	0.588 ± 0.021	0.830	0.704–0.908
AHCP	0.644 ± 0.022	0.747	0.560–0.862	0.637 ± 0.017	0.940	0.896–0.968
APCRP	0.804 ± 0.008	0.855	0.749–0.921	0.801 ± 0.007	0.871	0.776–0.930

SD, standard deviation; ICCs, inter- and intraclass correlation coefficients; CI, confidence interval; APCR, anterior/posterior vertebral body height compression ratio; AHCP, anterior vertebral body height compression percentage; APCRP, anterior/posterior vertebral body height compression ratio percentage.
*Lowest values of each measurement methods according to the different observers.

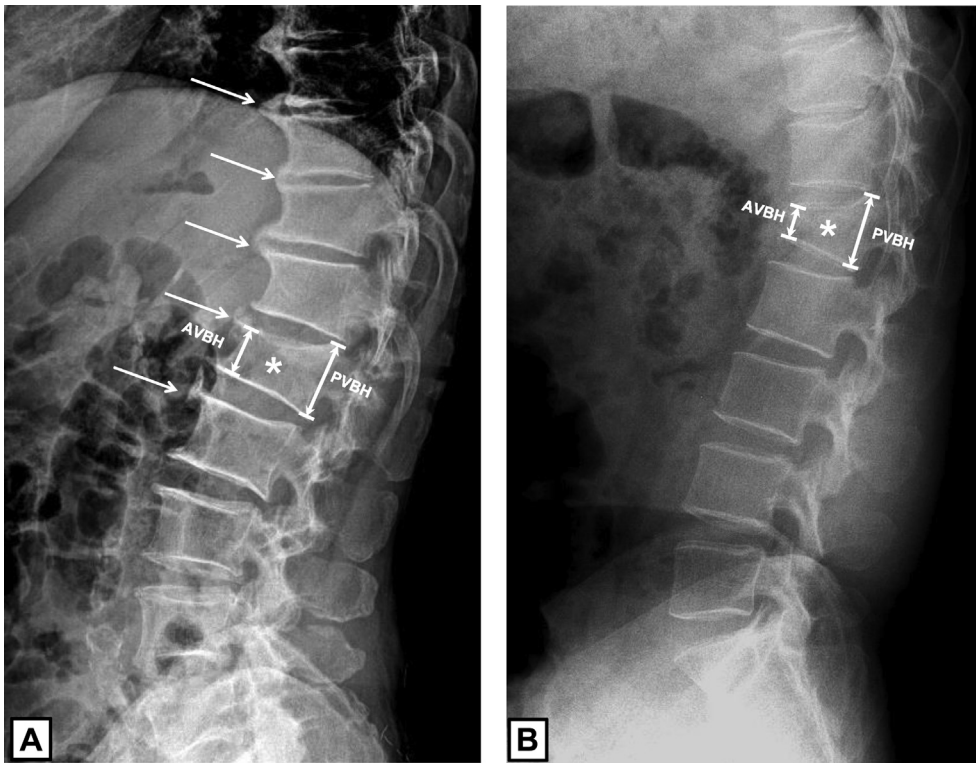

Figure 2. Different results according to measurement technique in patients with age-related degenerative deformity of the anterior column. (**A**) A thoracolumbar plain radiograph showing anterior osteophyte, spur, and bony bridge formation (*arrows*) in a 62-year-old male patient with a burst fracture at L1 (*asterisk*) that may interfere with the accuracy of the anterior vertebral body height compression percentage (AHCP) and anterior/posterior vertebral body height compression ratio percentage (APCRP) methods in the aged >50 year group. (**B**) A thoracolumbar plain radiograph without the presence of anterior osteophyte or bony spur formation in a 36-year-old male patient with a burst fracture at L1 (*asterisk*). The APCRP method is performed by measuring the anterior and posterior body height of the fractured vertebra only. Therefore, it is relatively less influenced by age-related degenerative changes compared with the AHCP and APCRP measurement methods using multiple AVBHs of the adjacent vertebrae. AVBH, anterior vertebral body height; PVBH, posterior vertebral body height.

by age, the APCR method was the most reliable and least variable technique, whereas the AHCP method showed acceptable reliability, albeit to a lesser than APCR. Variability between the 3 measurement methods was greater in the aged >50 year group compared with the aged <50 year group, presumably due to degenerative changes in the vertebral body contour.

This study is not without limitations. The total number of participants was relatively small and only a single center was included. However, a single center study has several advantages, including a consistent setting for radiographic modality and the same picture archiving communication system software tools used for measurement. Next, there was no assessment of the comparison between our measurement data using plain radiographs and data from CT scans, which is one of the most commonly obtained imaging modalities in acute trauma patients. However, a plain radiograph is the most basic and fastest possible imaging tool in spine patients including acute trauma. Moreover, additional time for performing CT scans and for image reconstruction is required, and repeated CT scanning is limited due to radiation hazards. Moreover, we used plain radiographs taken in the lateral position instead of weight-bearing radiographs. In the injured spine, loading can cause significant changes, as has been suggested by a recent study.[35] For this reason, the authors believe that radiographic images should always be obtained in the upright or weight-bearing position to reduce variability and to best represent spinal alignment under physiologic loads. However, in the acute injury setting this is seldom possible. Therefore, we concluded that lateral position radiographs, which are more commonly used in the initial stage for fracture patients, are a more realistic and practical method. In addition, although the age of 50 years was chosen as the cutoff for subgroup analyses as it was the median age, it was based only on the data of the present study. Therefore, we were unable to determine a specific age for selecting the most reliable measurement technique. This study also

included a separate assessment of the reliability of each measurement method and may provide the background information needed for other studies to determine the "gold standard" method for specific conditions.

The VBHL measurement method has not been included in various classifications used recently, including the AOSpine, Thoraco-Lumbar Injury Classification and Severity score and Load sharing classification, and it is difficult to directly use it for decision-making concerning spine surgery. However, because the results and reliability differ according to measurement method, it is necessary to present the measurement method when presenting the compression ratio. It is expected that the definition of the standard measurement technique will be needed to minimize concerns related to insurance and disability decisions, and we expect that the results of this study will help in doing so. Ultimately, standardization of imaging measurement parameters and outcome measures is warranted for both surgical and social reasons, including health care insurance, subsequently leading to high-quality research, clear evidence-based guidelines, and eventually a more informed and meaningful clinical decision-making process leading to better patient care.

CONCLUSIONS

We recommend the APCR method as the first-line technique and the AHCP method as an alternative technique for measuring VBHL in TL burst fractures.

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