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Natural changes of traumatic vertebral compression fractures during the first 6 months in patients visiting for disability certificates

A retrospective observational study

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Abstract

To identify the natural changes of traumatic vertebral compression fractures during the first six months in patients visiting for disability certificates after conservative treatment.

Data of patients who visited the rehabilitation medicine department of a university hospital for disability certificates concerning traumatic vertebral compression fractures from 2015 to 2018 were reviewed. Those who visited 180 to 210 days after injuries were included, and those who received invasive procedures for compression fractures were excluded. The anterior and posterior heights, local kyphotic angle of compression fractures, and upper and lower vertebrae on initial and follow-up images were measured and compared. Compression ratio was calculated by vertebral body compression ratio and anterior vertebral body compression percentage. Thoracic and lumbar traumatic fractures were also compared.

Among 110 patients, 61 patients met the criteria. After six months, the anterior height of compression fractures decreased more than 4 mm, which implies the development of new compression fractures. The compression ratio and local kyphotic angle increased significantly without affecting the upper and lower vertebrae. Thoracic and lumbar compression fractures showed similar changes.

Traumatic vertebral compression fractures change significantly during the first six months. This study could warrant 6 months of waiting for issuance of disability certificates for patients with traumatic vertebral compression fractures.

Abbreviations: ANOVA = analysis of variance, AVBCP = anterior vertebral body compression percentage, BMD = bone mineral density, DXA = dual-energy X-ray absorptiometry, ICC = intraclass correlation coefficient, MCID = minimal clinically important difference, VAS = visual analog scale, VBCR = vertebral body compression ratio, VCFs = vertebral compression fractures.

Keywords: compression fracture, trauma, disability

1. Introduction

Spinal injuries after major trauma are common, and thoracic and lumbar regions account for 75% to 90% of spinal fractures.[1,2] Treatment strategies are guided by radiological parameters that indicate instability and deformity, and pain is related to vertebral height loss and increased kyphosis.[1,3,4]

Further height loss was observed in osteoporotic vertebral compression fractures (VCFs) because of the impaired healing process of the osteoporotic bone.[5] In osteoporosis, decreased bone mass and the degeneration of bone structures change pathological and inflammatory responses to fractures, and a gradual decrease in vertebral height was found in serial evaluations of osteoporotic VCFs.[5–7] Traumatic VCFs also showed the progression of vertebral collapse in studies involving long-time follow-up.[4,8] Six months after the onset is the minimum duration required before a disability certificate can be issued in several countries;[9–11] it is also the criterion for distinguishing short-term and long-term disability.[12–14] However, it was not reported that changes of traumatic VCFs in the first 6 months were significant enough to justify the waiting of six months for a disability certificate. It is important because disability claims are time-consuming and require hiring of an attorney to overcome the high denial rate of claims, which was >50%.[15–18]

The purpose of this study was to identify the natural changes of traumatic VCFs during the first six months in patients visiting for disability certificates after conservative treatment.

2. Methods

2.1. Study population

This retrospective study evaluated the medical records and radiographs of patients who visited the outpatient clinic of the

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The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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rehabilitation medicine department of a university hospital for disability certificates concerning traumatic VCFs on the thoracic or lumbar spine from 2015 to 2018. The inclusion criteria were:

(1) older than 18 years,
(2) initial images were transferred to and available to be measured in a picture archiving and communication system, Marosis m-view 5.4 (Marotech, Seoul, Korea), and
(3) images for disability certificates were taken between 180 and 210 days after the injury.

The exclusion criteria were:

(1) vertebroplasty or kyphoplasty,
(2) spinal fusion, and
(3) more than 2 levels of compression fractures.

Patients' data, such as age and sex, and related information on their traumatic VCFs as well as bone mineral density (BMD) evaluated with dual-energy X-ray absorptiometry (DXA) were collected. Information about the DXA devices used and the scanned body area for BMD acquisition was obtained. For BMD measurement, values related to the total lumbar spines are recommended because the lowest single lumbar spine T-score overestimates the presence of osteoporosis as compared with the total lumbar spine T-score.[19,20] Moreover, abnormal spines such as lumbar VCFs should be excluded.[19] However, selective exclusion of VCFs at the L2 or L3 level was not possible in this retrospective study. Instead, the hip T-score, which was the lowest value between the femoral neck T-score and the total proximal femur T-score, was used.[19] BMD values were converted to the standardized BMD by using previously reported formulas.[21,22]

Concerning traumatic VCFs, the date of the injury, the cause and level of traumatic VCFs, the date of visit for disability certificates, and the visual analog scale (VAS) were assessed. The study protocol was reviewed and approved by the Institutional Review Board of the university hospital. Informed consent was waived by the board.

2.2. Radiological measurement

Initial images obtained before conservative treatment and follow-up images taken between 180 and 210 days were measured and compared. The anterior and posterior vertebral heights of traumatic VCFs and vertebral bones one level higher and 1 level lower were measured.[23,24] The compression ratio was calculated by 2 methods:

(1) vertebral body compression ratio (VBCR) at each vertebral level as [1–(anterior height/posterior height)] × 100 and
(2) anterior vertebral body compression percentage (AVBCP) at VCF level as (1–anterior height of VCF/[(anterior height of upper vertebra + anterior height of lower vertebra)/2]) × 100.[1,25–27] The angle between the superior and inferior endplates of each vertebral bone was measured as the local kyphotic angle.[1,25,28]

Because normal lateral spinal curves differ between the thoracic and lumbar levels, a wedge deformity caused by a traumatic VCF could increase thoracic kyphosis and decrease lumbar lordosis.[29] Severe lumbar traumatic VCFs could even lead to lumbar kyphosis. Due to this different nature, thoracic and lumbar traumatic VCFs were compared. All the images were blindly reviewed by 2 of the investigators and the average values were used for analysis.

2.3. Statistical analysis

All statistical analyses were performed using SPSS version 14.0 (SPSS Inc., Chicago, IL). Interobserver reliability was checked with intraclass correlation coefficient (ICC). The 2-way mixed-effect Cronbach's alpha was used as ICC,[30] and the ICC values of the measurements of vertebral heights and local kyphotic angle were calculated. The changes in parameters were analyzed with paired t test. The differences between initial and follow-up images were designated as the values of changes. The differences of VBCR and local kyphotic angle of VCFs and adjacent vertebral bones were evaluated by Pearson correlation analysis, and if there was no correlation between vertebral bones then the changes were compared by one-way analysis of variance (ANOVA) with a Tukey post hoc test. The relationship between the changes and BMD or age was determined using Pearson correlation analysis. A comparison between thoracic and lumbar traumatic VCFs was performed by the independent t test. A P value of $< .05$ was considered statistically significant, and a P value $< .017$ was used for a Tukey post hoc test.

3. Results

Among the 110 patients considered in the study, 16 received vertebroplasty or kyphoplasty for traumatic VCFs, 22 patients received spinal fusion after the injury, and 11 patients had traumatic VCFs at more than 2 levels. These patients were excluded.

The remaining 61 patients included 28 men and 33 women. The mean age was 54.2 ± 13.4 years (range, 23–79 years), and 191.9 ± 7.8 days (range, 181–210 days) had passed from the time of the injury. The causes of injury were traffic accidents in 27 patients, slips in 17, and falls in 17. The VAS score was 6.7 ± 1.6. Twenty-three patients had thoracic VCFs, and 38 patients had lumbar VCFs. The spine levels involved were T3 (n=2), T5 (n=2), T7 (n=1), T8 (n=1), T9 (n=2), T10 (n=1), T11 (n=2), T12 (n=12), L1 (n=11), L2 (n=14), L3 (n=10), and L4 (n=3).

Vertebral heights showed a high interobserver reliability (ICC .969–.988) and local kyphotic angle had decent values (ICC .827–.918), all of which were greater than .8, the statistically acceptable threshold.[28]

Table 1 shows the changes between the initial time and six months later. The anterior and posterior heights decreased, while VBCR, AVBCP, and local kyphotic angle increased, and the changes were statistically significant in VCFs and the upper vertebral bones. In the lower vertebral bones, the changes of heights were significant, unlike those of VBCR and local kyphotic angle.

The changes of VBCR of VCFs and the upper and lower vertebral bones were not correlated with each other based on the results of the Pearson correlation analysis (VCFs vs. upper vertebral bones, P=.908; VCFs vs. lower vertebral bones, P=.950; and upper vertebral bones vs. lower vertebral bones, P=.988). One-way ANOVA results were statistically different between 3 bones (P < .001). The changes of VBCR were significantly higher in VCFs than in the upper and lower vertebral bones (P < .001 each) per the results of a Tukey post hoc test, while those were not statistically different between upper and lower vertebral bones (P=.718) (Fig. 1).

Changes of local kyphotic angle of 3 bones were also not correlated with each other (VCFs vs. upper vertebral bones, P=.767; VCFs vs. lower vertebral bones, P=.058; and upper vertebral bones vs. lower vertebral bones, P=.803). Those values

Table 1

Changes of vertebral heights and local kyphotic angle between the initial time and six months later.

	Initial time	Six months later	P	Difference
Compression fracture				
Anterior height (mm)	22.9±5.0	18.9±5.0	<.001	4.0±2.3
Posterior height (mm)	30.6±5.0	29.4±5.2	<.001	1.2±1.0
Vertebral body compression ratio (%)	25.3±10.4	36.1±12.0	<.001	10.8±7.6
Local kyphotic angle (°)	11.6±4.6	14.6±4.8	<.001	3.1±3.2
Anterior vertebral body compression percentage (%)	17.1±12.1	29.2±14.2	<.001	12.1±8.3
Upper vertebra				
Anterior height (mm)	26.3±4.3	25.2±4.2	<.001	1.1±1.0
Posterior height (mm)	30.4±4.8	29.5±4.9	<.001	0.9±1.0
Vertebral body compression ratio (%)	13.2±5.4	14.2±5.8	.012	1.0±3.0
Local kyphotic angle (°)	6.3±2.6	6.7±2.7	.011	0.5±1.5
Lower vertebra				
Anterior height (mm)	28.8±4.5	27.9±4.5	<.001	0.9±0.7
Posterior height (mm)	31.1±4.7	30.2±4.7	<.001	0.9±0.9
Vertebral body compression ratio (%)	6.9±9.9	7.2±9.7	.264	0.3±2.1
Local kyphotic angle (°)	3.5±4.8	3.9±4.3	.057	0.4±1.5

Data are expressed as mean±SD.

were statistically different between 3 bones by 1-way ANOVA ($P<.001$), and the changes of local kyphotic angle were significantly higher in VCFs than in the upper and lower vertebral bones ($P<.001$ each), but those of the upper and lower vertebral bones were not statistically different ($P=.959$) by a Tukey post hoc test (Fig. 2).

Twenty-four patients had the hip BMD data evaluated with DXA after trauma. The results were acquired with Lunar ($n=10$; GE Healthcare, Madison, WI), Hologic ($n=6$; Hologic Inc., Bedford, MA), Norland ($n=4$; Norland at Swissray, Fort Atkinson, WI), and Dexxum ($n=4$; Osteosys, Seoul, Korea) densitometers. The lowest hip T-score was -1.1 ± 1.2, and only one patient met the World Health Organization definition of osteoporosis (T-score ≤-2.5).[31] The standardized BMD of the hip was $0.766\pm0.135\,g/cm^2$. This T-score and standardized BMD were not correlated with the differences of VBCR, AVBCP, and local kyphotic angle of 3 bones by Pearson correlation analysis. These BMD values were negatively correlated with age by Pearson correlation analysis.

Age showed positive correlations with the differences of VBCR ($r=.433$, $P<.001$) and local kyphotic angle ($r=.308$, $P=.016$) of VCFs, and with those of AVBCP ($r=.437$, $P<.001$) by Pearson correlation analysis. VBCR and local kyphotic angle of the upper and lower vertebral bones were not correlated with age by Pearson correlation analysis. The sex of the patients was not correlated with any differences of VCFs.

Table 2 shows the comparison of changes between thoracic and lumbar traumatic VCFs. Some of the absolute values of vertebral heights were different between the thoracic and lumbar vertebrae; however, the changes of VBCR, AVBCP, and local kyphotic angle of all 3 bones were not different between thoracic and lumbar traumatic VCFs.

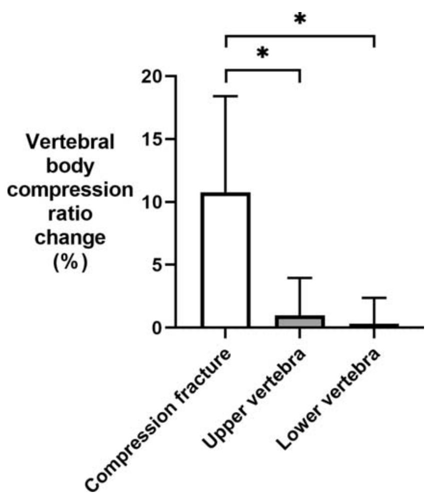

Figure 1. Comparison of changes of compression ratio measured with vertebral body compression ratio between compression fracture and upper and lower vertebrae. *$P<.017$ by a Tukey post hoc test.

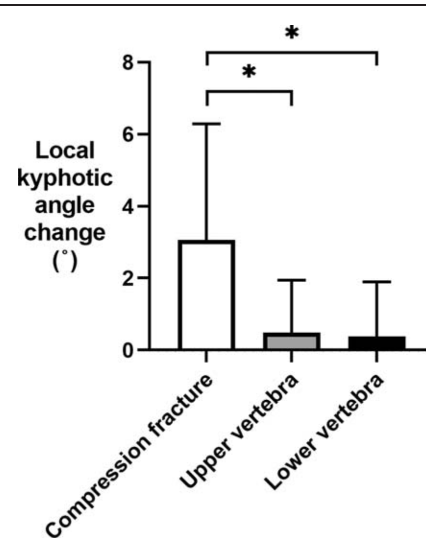

Figure 2. Comparison of changes of local kyphotic angle between compression fracture and upper and lower vertebrae. *$P<.017$ by a Tukey post hoc test.

Table 2

Comparison of changes of vertebral heights and local kyphotic angle between thoracic and lumbar compression fractures.

	Thoracic spine (n=23)	Lumbar spine (n=38)	P
Compression fracture			
Anterior height (mm)	3.9±2.1	4.1±2.4	.780
Posterior height (mm)	1.8±1.3	0.9±0.7	.003
Vertebral body compression ratio (%)	10.6±7.9	10.9±7.6	.903
Local kyphotic angle (°)	3.3±3.0	2.9±3.4	.712
Anterior vertebral body compression percentage (%)	13.0±9.1	11.6±7.9	.521
Upper vertebra			
Anterior height (mm)	1.2±1.3	1.1±0.8	.569
Posterior height (mm)	1.2±1.4	0.7±0.5	.091
Vertebral body compression ratio (%)	0.4±3.5	1.4±2.6	.223
Local kyphotic angle (°)	0.1±1.8	0.7±1.1	.092
Lower vertebra			
Anterior height (mm)	1.2±0.8	0.8±0.6	.045
Posterior height (mm)	1.3±1.1	0.7±0.6	.021
Vertebral body compression ratio (%)	0.1±2.1	0.4±2.1	.583
Local kyphotic angle (°)	0.1±1.3	0.6±1.6	.270

Data are expressed as mean±SD.

4. Discussion

In this study, significant changes were observed on the traumatic VCFs during the first six months. Considering the initial values, the anterior height decreased more than the posterior height did, and this was reflected in the increase of VBCR, AVBCP, and local kyphotic angle. In addition, thoracic and lumbar VCFs showed similar changes.

The vertebral heights are known to decrease with aging, but the change is gradual and develops over decades.[32,33] A height loss of more than 4 mm is suggested as an indicator for a true vertebral fracture.[34,35] In this study, the anterior height of VCFs showed over 4-mm change during the first six months. A significant height loss occurred during six months in the injured vertebrae. This change corresponds to 18.1±10.4% of the initial height and was smaller than that of osteoporotic VCFs, which decreases by 21.8±14.4% at 6 months.[5] Traumatic VCFs were reported to show 19.8±7.4% height loss after 2 years,[8] and therefore about 90% of this height loss was assumed to be obtained during the first six months.

Various methods of measurement were suggested for the compression ratio of VCFs;[25,26] most physicians usually adopt VBCR.[1] However, VCFs may involve the entire vertebral body including the posterior height and the compression may be underrated, AVBCP calculated with the mean value of anterior heights between upper and lower vertebrae was recommended in case the adjacent vertebrae were not affected.[26,27] In the current study, VBCR of traumatic VCFs changed from 25.3±10.4% to 36.1±12.0% during six months with an increment of 10.8±7.6%, and AVBCP from 17.1±12.1% to 29.2±14.2% with 12.1±8.3% change. The differences between VBCR and AVBCP in this study were below 27.7%, which was reported to be the largest difference between the 2.[27] The posterior height of VCFs showed similar changes with the anterior and posterior heights of the upper and lower vertebral bones, and differences of VBCR between the 3 bones were not correlated with each other. Therefore, the posterior height of VCFs and the height changes of the adjacent vertebrae could be interpreted as not affected by VCFs, and both VBCR and AVBCP could be used as the evidence of the increase of the compression ratio in this study.

AVBCP of osteoporotic VCFs was reported to increase from 28.2±16.9% to 50.6±20.0% after more than 1 year with a difference of 22.2±20.5%.[6] Although an exact comparison was not possible because the time of follow-up measurement was different, the increase in AVBCP of traumatic VCFs at 6 months was much lower than that of osteoporotic VCFs measured more than 1 year later. Although minimal clinically important difference (MCID) of VCFs was not reported, when the change of 12.1±8.3% was compared to the initial value of 17.1±12.1%, this change was more than 17.2% of the baseline value, which was the suggested percentage of general MCID.[36]

With these changes in compression ratio, the disability grade could be increased because the grade is different between <25% compression and 25% to 50% compression.[37,38] The increase of the disability grade could increase the possibilities of allowance of the disability claim.[18]

There have been diverse measurement methods of kyphosis, with or without utilizing adjacent vertebrae.[39] The Cobb's angle, which is the angle between the superior endplate of the upper vertebra and the inferior endplate of the lower vertebra,[26] can have different aspects between thoracic and lumbar VCFs because of normal physiologic thoracic kyphosis and lumbar lordosis before an injury.[29] A gradual increase in the vertebral body from T1 to L4 also has an influence on the Cobb's angle.[40] Therefore, local kyphotic angle, also known as wedge angle, was measured in this study.[1,25] The local kyphotic angle of osteoporotic VCFs with necrotic area less than 25% of the entire vertebral body changed from 11.7±6.5° initially to 15.9±6.7° at six months.[5] Local kyphotic angle of traumatic VCFs in the current study showed less value than osteoporotic VCFs, but the change was more than 17.2% of baseline local kyphotic angle as MCID.[36]

The total lumbar spine T-score with the exclusion of lumbar VCFs was not available, and the hip T-score was chosen.[19,41] To reflect the various densitometers used, standardized BMD was calculated. The hip T-score and standardized BMD were not correlated with the changes of VBCR, AVBCP, and local kyphotic angle of the 3 bones.

Age was positively correlated with the differences of VBCR and local kyphotic angle of VCFs and with those of AVBCP. Old age was a known risk factor of further compression in osteoporotic[3] or traumatic VCFs.[4] In this study, only 1 man and 6 women met the age indications for the BMD test (men aged ≥70 years and women aged ≥65 years).[19] Even in this relatively young patient group, the effect of aging was evident.

BMD declines with aging,[42] and the hip T-score and standardized BMD were correlated with age in this study. However, BMD itself was not correlated with the changes of VCFs. A recent study reported that BMD was a risk factor for VCFs, but the association of BMD and VCFs was not high, and age could be associated with VCFs even in patients with normal BMD.[43] Another study regarding osteoporotic VCFs stated that the progression of canal encroachment on magnetic resonance imaging was correlated with age but not with BMD, and the quality of the bone declines with aging even if BMD remains high.[6] Traumatic VCFs were unrelated to osteoporosis and the decrease in vertebral heights would have progressed without the influence of BMD. However, this interpretation needs further validation in consideration that only some patients underwent evaluation for BMD because most patients were not in the age indicated for BMD testing in this study.

The pain at 6 months had a VAS score of 6.7 ± 1.6 in the present study. The VAS score in traumatic VCFs was reported to decrease from 9.8 ± 0.4 initially to 2.0 ± 0.9 after 2 years.[8] A study about osteoporotic VCFs described that the initial VAS score of 8.1 ± 2.0 decreased to 3.1 ± 2.1 after 3 months,[44] and another study found that the VAS score was 2.3 ± 1.2 at 6 months in osteoporotic VCFs.[5] Although a direct comparison was not possible between studies, pain reduction was estimated to be slower in traumatic VCFs than in osteoporotic VCFs, in contrast to the slower and less progression of kyphosis in traumatic VCFs than in osteoporotic VCFs. This assumption was supported by previous studies that found that pain and kyphotic deformity were not related in traumatic VCFs.[8,45]

Due to the different nature of the thoracic and lumbar spines,[29,40] we compared only the changes from initial time to 6 months later between thoracic and lumbar VCFs. Although some of the changes of vertebral heights were significantly different between thoracic and lumbar spines, the changes of compression ratio (VBCR, AVBCP) and local kyphotic angle were not. The progression of the wedge deformity of VCFs was not significantly different between the thoracic and lumbar spines.

This study has several limitations. First, age and sex were not controlled in the analyses. To decrease individual variability, this study used the paired *t* test. However, to control these parameters strictly, further studies with large numbers of patients using an age- and sex-stratified design are needed. Second, BMD could affect this result. All included patients remembered that they had neither back pain nor osteoporosis before the injury. BMD evaluated with DXA was available in only some eligible patients, and this BMD could not reflect premorbid BMD because it was assessed after the injury. However, the traumatic VCFs of the included patients were not severe enough to receive vertebroplasty, kyphoplasty, or spinal fusion; therefore, the lowest T-score of these patients before the injury could be assumed not low. Third, the change of traumatic VCFs during 180–210 days from the injury was evaluated only. Disability certificates are available to be written after 6 months and thereafter, and some patients visited the hospital after a long, unspecified time. Prospective studies with a periodic evaluation should be used to clarify the long-term natural course of traumatic VCFs.

5. Conclusions

In conclusion, traumatic VCFs changed significantly during the first 6 months after conservative treatment. The anterior height decreased, compression ratio measured with VBCR and AVBCP, and local kyphotic angle increased. Thoracic and lumbar VCFs showed similar changes. This study could warrant the 6 months of waiting for the issuance of disability certificates to patients who had traumatic VCFs.

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