Relationship Between Clinical Outcomes and Spontaneous Canal Remodeling in Thoracolumbar Burst Fracture

Young Jae Moon and Kwang-Bok Lee

■ OBJECTIVES: **To analyze the relationship between clinical factors and spontaneous canal remodeling.**

■ METHODS: **We evaluated computed tomography scans, before surgery, within a week after surgery, 6 months after surgery, and 12 months after surgery. Thirty-eight consecutive patients who underwent posterior fixation and fusion after thoracolumbar burst fractures were included in. Factors potentially affecting the postoperative degree of reduction and spontaneous spinal remodeling were defined as age, location, degree of change of anterior vertebral compression ratio, fracture type of the retropulse bone, presence of injury to the posterior longitudinal ligament, and posterolateral complex fracture. Multiple regression analyses were conducted on these factors to analyze the extent of their influence on the reduction and resorption rates.**

■ RESULTS: **The recovery rate of the anterior compression ($P = 0.003$) was significantly related to the reduction rate after surgery; in addition, the recovery rate of the anterior compression ($P = 0.022$) and the comminuted type of fracture ($P = 0.019$) were significantly associated with the resorption rate after surgery.**

■ CONCLUSIONS: **During posterior fixation, the degree of the reduction of the vertebral body by distraction can affect the degree of postoperative reduction and spontaneous bone remodeling. Therefore, close attention must be given to the indirect reduction technique through distraction during the operation. Because comminuted fracture fragments affect spontaneous canal remodeling, the degree of postoperative resorption can be estimated by preoperative computed tomography imaging.**

INTRODUCTION

Thoracolumbar burst fractures occur when a posterior bone fragment of the vertebral body retropulses into the canal as the result of a bending force.[1,2] One treatment modality for this condition is posterior fixation. Even though patients have undergone posterior fixation, there have been controversial findings regarding whether any bone fragments that exist in the canal should be removed directly ("decompression")[3,4] or reduced indirectly. Indirect reduction is possible because of the ligamentotaxis effect of the posterior longitudinal ligament (PLL) and occurs when surgeons perform posterior distraction through posterior instrumentation without decompression.[5,6] Recently, however, some studies have reported that indirect reduction by posterior distraction is as effective as the direct decompression method.[7] Furthermore, because spontaneous canal remodeling occurs when retropulsed fragments are present, posterior stabilization without decompression constitutes an appropriate surgical treatment option.[8]

Nevertheless, factors that affect spontaneous canal remodeling have not yet been identified. Therefore, we investigated the relationship between clinical factors and spontaneous canal remodeling. We measured the volume of the bone fragments that encroached on the spinal canal at various time points by using 3-dimensional (3D) computed tomography (CT) images. As a result, we tried to determine which factors had a significant impact on spontaneous bone remodeling by using multiple regression analyses.

Key words
- Burst fracture
- Reduction rate
- Resorption rate
- Spontaneous canal remodeling

Abbreviations and Acronyms
CT: Computed tomography
MRI: Magnetic resonance imaging
PLC: Posterolateral complex
PLL: Posterior longitudinal ligament
3D: Three-dimensional

Department of Orthopedic Surgery, Research Institute of Clinical Medicine of Chonbuk National University-Biomedical Research Institute of Chonbuk National University Hospital Chonbuk National University Medical School, Jeonju, Korea

To whom correspondence should be addressed: Kwang-Bok Lee, M.D. [E-mail: osdr2815@naver.com]

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PATIENTS AND METHODS

This study was performed by the approval of the Institutional Review Board of Chonbuk National University Research Council (IRB-2014-37).

Patients

In this retrospective study, we analyzed 38 consecutive patients who underwent posterior fixation and fusion after thoracolumbar burst fracture from September 2010 to November 2013. Mean age was 46.0 years (±15.79 years, range: 17–76 years), and the average follow-up period was 14.36 months (±4.82 months, range: 12–27 months). Twenty-two patients were male, and 16 were female. The location of the burst fracture was T11 (2 cases), T12 (2 cases), L1 (16 cases), L2 (10 cases), L3 (6 cases), and L5 (3 cases). Mechanisms of injury included falling (22 cases), car accidents (8 cases), being crushed under a heavy object (4 cases), pedestrian accidents (2 cases), and other accidents (2 cases). The waiting period from the time of the injury until surgery was approximately 3.6 days (±4.28 days, range: 0–16 days). Any participants who had pathologic fractures or burst fractures along with osteoporosis, compression fractures, or fractures that were at least 6 weeks old were excluded from the study.

Methods

All patients underwent 3D-CT of the thoracolumbar region before surgery, within a week after surgery, 6 months after surgery, and 12 months after surgery. The reduction rate was defined as the difference between the volume of the canal that was encroached by bone fragments preoperatively and the measured volume within a week postoperatively as a percentage. The resorption rate was defined as the difference between the volume of the canal encroached by bone fragments postoperatively and the measured volume 12 months postoperatively and was expressed as a percentage.

The possible factors that could affect the postoperative reduction rate and spontaneous canal remodeling were sex, age, thoracolumbar fracture level (T11–L1, L2–L5), differences in the anterior vertebral compression ratio measured both preoperatively and postoperatively, the fracture type (fragment, comminuted) of the posterior bone fragment, the retropulse fragment pattern (simple retrolisthesis, reverse pattern), the presence of PLL injury, and fracture of the posterolateral complex (PLC).

We defined that the fragment type was when the bony fragment in the spinal canal had sustained cortical continuity (Figure 1A) and the comminuted type was when the bony fragment in the spinal canal was fractured into several pieces (Figure 1B). In the retropulse fragment pattern, a simple retrolisthesis pattern was defined as a state in which the fractured bone fragment had just entered the canal (Figure 1A–B). The reverse pattern was when the bony fragment was reversed and the cancellous portion was exposed in the spinal canal (Figure 1C–D).

PLL injury was defined as a discontinuity or nonvisualization of the black stripe, and high signal intensity on T2 sagittal images on preoperative magnetic resonance imaging (MRI). Fracture of PLC was identified with preoperative CT, and MRI was used to assess the integrity of the PLC consisting of supraspinal and infraspinal ligaments, facet capsules, and ligamentum flavum. PLC injury was defined as disrupted PLC components on T1 sagittal MRI and high signal intensity in the region of PLC elements on T2 sagittal images or fat saturation sagittal MRI. We performed MRI using a 3-T imager (Magnetom Verio; Siemens Medical Solutions, Erlangen, Germany), and the multi-echo data image combination 3D sequence. All images were obtained with spine-array coils, with the patient in the supine position.

Operation

All surgeries were performed by 1 surgeon (K.B.L.). The patient was placed in the prone position, and postural reduction was maintained. Except in cases with fractured bones, posterior fixation was performed proximal and distal to level 2 of the fractured bone via the use of a Perfix Spinal System (U & I, Seoul, Korea) implant. The rod was inserted into the pedicle screw and fixed in the state of the distraction fully performed by rod spreader before fixing. The decortication of the laminar space was conducted, and posterior fusion was performed on both sides by the use of an autogenously corticocancellous bone graft that had been harvested from the posterior iliac crest.

CT Scan Measurements of the Bone Fragments Encroaching on the Spinal Canal

The spinal canal encroaching volume was measured with the SOMATOM Definition CT scanner (Siemens, Berlin, Germany). The window width was 1500 Hounsfield units, and the window level was 150 Hounsfield units. The thickness of the CT slice was 2 mm, and the gantry angle was 0°. The interpretations and measurement were performed on the Marosis Stand-Alone PACS view imaging system (Marotech, Seoul, South Korea). The axial view of the CT scan was used to check all the slices of the canal encroached bone fragments, and then their sum was obtained by measuring each slice's area.

The volume of each fragment was calculated by multiplying the CT thickness (2 mm) by the total sum of each area. The area of each slice was measured through the regions of interest curve tool of the PACS system. For example, as shown in Figure 2, there was a bone fragment retropulse in 6 slices. All the slices of the measured fragment area were summed and multiplied by the CT thickness (2 mm). The result of 1436.7 mm^3 was obtained using the following equation:

[113.54 mm^2 (Figure 2A) + 116.41 mm^2 (Figure 2B) + 140.27 mm^2 (Figure 2C) + 132.85 mm^2 (Figure 2D) + 119.57 mm^2 (Figure 2E) + 95.71 mm^2 (Figure 2F)] × 2 mm = 1436.7 mm^3.

Three orthopedic surgeons who had been well informed of the volume measurement method and who had 4, 4, and 3 years of orthopedic experience, respectively, assessed the volume using the CT images obtained before the procedure, postoperatively, and during outpatient follow-up (at 6 months and 12 months).

Evaluation of Neurologic Status

The changes in the degree of general symptoms and neurologic symptoms were measured. The modified Frankel grading system was used to assess changes in the patients' neurologic symptoms (Table 1).

Statistical Analysis

Multiple regression analysis was performed on the factors affecting the reduction rate and the bone resorption rate. It was