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ORIGINAL ARTICLE

Dynamic Computed Tomography Myelography including the Prone Position as a Reliable Preoperative Imaging Method for Osteoporotic Vertebral Fracture with Neurological Deficits: A Preliminary Report of Three Cases

[1]Toru Funayama, [2]Toshinori Tsukanishi, [3]Kentaro Mataki, [4]Tetsuya Abe, [5]Hiroshi Noguchi, [6]Hiroshi Kumagai
[7]Katsuya Nagashima, [8]Kousei Miura, [9]Masao Koda, [10]Masashi Yamazaki

ABSTRACT

Aims: Delayed paralysis after osteoporotic vertebral fracture (OVF) in the elderly is caused by severe compression on the spinal cord or the cauda equina from the collapsed vertebral fragment that is retropulsed into the spinal canal. Patients with retropulsion of the vertebral fragment that occupies approximately 40% or more of the spinal canal likely develop delayed paralysis, suggesting that narrowing of 40% is the critical point. However, whether or not a neural decompression procedure during posterior instrumentation surgery, such as laminectomy should be performed during the surgery is still controversial. We performed dynamic computed tomography myelography (CTM) including the prone (surgical) position with OVF to investigate if the severity of spinal cord and cauda equina compression during the surgery could be estimated in advance.

Materials and methods: The CTM was examined in 3 OVF patients (1 man and 2 women; mean age, 84 years) with neurological deficit in the supine and prone (surgical) positions to accurately estimate the necessity of decompression during surgery.

Results: The spinal narrowing was 50% or higher in the supine position, but was less than 40% in the prone position in two patients (fracture at the T11 and L1 vertebrae), indicating that decompression was not necessary. Decompression was required in one patient (fracture at the L2 vertebra) with a high narrowing rate of 57% in the supine position and 56% in the prone position.

Conclusion: Diagnostic imaging in the supine position alone will not help estimate the severity of intraoperative spinal cord or cauda equina compression because the degree of vertebral instability varies in each patient with OVF.

[1,4,5]Assistant Professor, [2,3,6-8]Spine Surgeon, [9]Associate Professor, [10]Professor

[1,4-10]Department of Orthopedic Surgery, University of Tsukuba Tsukuba, Ibaraki, Japan

[2]Department of Orthopedic Surgery, Kenpoku Medical Center Takahagi Kyodo Hospital, Takahagi, Ibaraki, Japan

[3]Department of Orthopedic Surgery, Ichihara Hospital, Tsukuba Ibaraki, Japan

Corresponding Author: Toru Funayama, Assistant Professor Department of Orthopedic Surgery, University of Tsukuba Tsukuba, Ibaraki, Japan, Phone: +81298533219, e-mail: funatoru3@gmail.com

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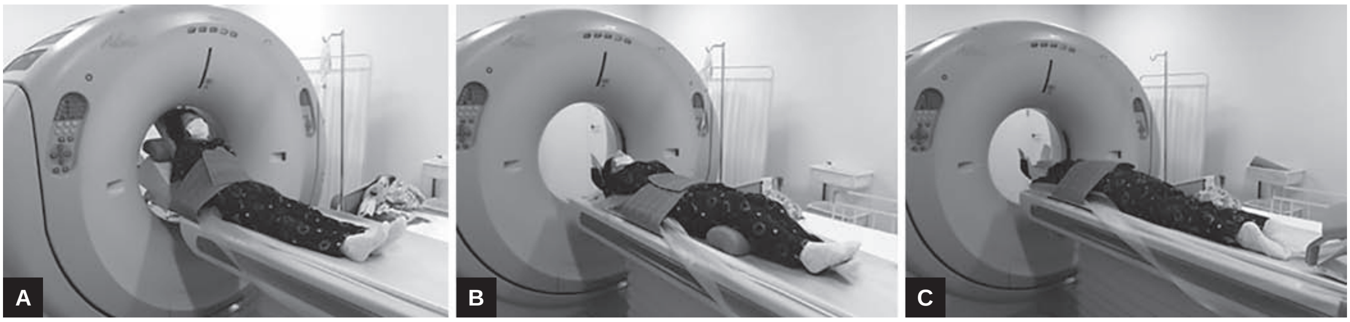
Key messages: Prone-position CTM is a new and simple preoperative imaging method to accurately evaluate whether intraoperative decompression will be required.

INTRODUCTION

Osteoporotic vertebral fracture occurs mostly in the thoracolumbar junction (T11 to L2).[1,2] While bone union will usually be achieved with conservative management, delayed union or nonunion is reported in about 10 to 35% of patients.[2-4] Some patients with delayed union or nonunion may suffer delayed lower limb paralysis caused by severe compression on the spinal cord or the cauda equina from a retropulsed vertebral fragment. Patients with retropulsion of the vertebral fragment that occupies approximately 40% or more of the spinal canal likely develop delayed paralysis, suggesting that narrowing of 40% is the critical point.[5,6]

Posterior instrumentation in the prone position is the most common surgical technique for OVF surgery.[7] Whether or not posterior neural decompression, such as laminectomy and pushing the posterior vertebral fragment back into the vertebral body should be performed during surgery is controversial.[8-11]

Recently, compression on the spinal cord and cauda equina from the retropulsed vertebral fragment under load was found to be the pathology of delayed paralysis, showing that compression on the spinal cord and cauda equina increases in the semisitting position and decreases in the supine position.[12]



Figs 1A to C: Dynamic CTM in the semisitting position (A) and supine position (B) as well as in the prone (surgical) position (C)

Given this observation, we performed dynamic CTM in the semisitting position and supine position as well as in the prone (surgical) position in three patients with OVF to investigate if the severity of spinal cord and cauda equina compression during the surgery could be estimated in advance (Fig. 1). No report on this preoperative procedure has been available to date.

CASE REPORTS

Case 1

An 87-year-old male patient visited a local clinic complaining of back pain with no identifiable cause and was diagnosed with OVF at the T11 vertebra. About 1 month later, he was referred to us with sudden weakness of the lower limbs, difficulty standing up, and inability to walk. The strength of the lower limbs (knee extension and ankle dorsiflexion) was rated 2 in the manual muscle test (MMT) at the initial consultation. The patient had difficulty of urination, which was a symptom of vesicorectal disorder. A plain x-ray showed that the body of the T11 vertebra was significantly collapsed when the patient was in the standing position (Fig. 2A), but the collapse was reversed when the patient was in the supine position (Fig. 2B). Vertebral instability was significantly affected by the position of the body. A T2-weighted magnetic resonance imaging (MRI) showed a high-intensity area where the collapsed posterior vertebral fragment significantly retropulsed into the spinal canal, firmly compressing the spinal cord (Fig. 2C). The CTM was performed in the semisitting, supine, and prone positions. Ratio of occupation by bony fragments of the spinal canal was calculated as the ratio in percentage of axial diameter of bony fragments to axial diameter of the spinal canal on axial CTM images.[10] Narrowing of the spinal canal due to bony fragment retropulsion was 64% in the semisitting position (Figs 3A and D) and 56% in the supine position (Figs 3B and E), but decreased to 39% in the prone position with the contrast medium flowing between the fragment and the spinal cord (Figs 3C and F). Spinal decompression was considered unnecessary based on the CTM images. Posterior spinal fusion of T9 to L1 without decompression was performed by using pedicle screws (ES2, Stryker Corp., Kalamazoo, Michigan, USA). Vertebroplasty with hydroxyapatite artificial bone substitute (Regenos, Kuraray Co., Ltd., Tokyo, Japan) was performed on the T11 vertebra (Fig. 2D). The patient's back pain disappeared after the surgery. The paralysis of the lower limb and symptoms of vesicorectal disorder improved immediately.

Case 2

An 87-year-old female patient visited a local clinic with lower back pain with no apparent cause and was diagnosed with OVF at the L1 vertebra. The patient gradually became aware of weakness of the lower limbs. When she presented to us after 2 months from the injury, the strength of the lower limbs (knee extension and ankle dorsiflexion) was rated MMT 4 in the left limb and MMT 1 in the right limb. A plain x-ray in the lateral position showed that she has a transitional vertebra and significant collapse of the body of the L1 vertebra. Vertebral instability was significant in flexion (Fig. 4A) and extension (Fig. 4B). A T2-weighted MRI showed a high-intensity area in the L1 vertebral body where the collapsed posterior vertebral fragment significantly retropulsed into the spinal canal, firmly compressing the spinal cord to the back (Fig. 4C). Narrowing of the spinal canal was 75% in the semisitting position (Figs 5A and D) and 50% in the supine position (Figs 5B and E), but decreased to 30% in the prone position, with the contrast medium flowing between the fragment and the spinal cord (Figs 5C and F). Spinal decompression was considered unnecessary based on the CTM images. Posterior spinal fusion of T11 to L4 without decompression was performed by using pedicle screws (SOLERA, Medtronic, Minneapolis, Minnesota, USA). Vertebroplasty with β-tricalcium phosphate artificial bone substitute (Affinos, Kuraray Co., Ltd., Tokyo, Japan) was performed on the L1 vertebra (Fig. 4D). The patient's lower back pain disappeared, and paralysis of the lower limb gradually improved.

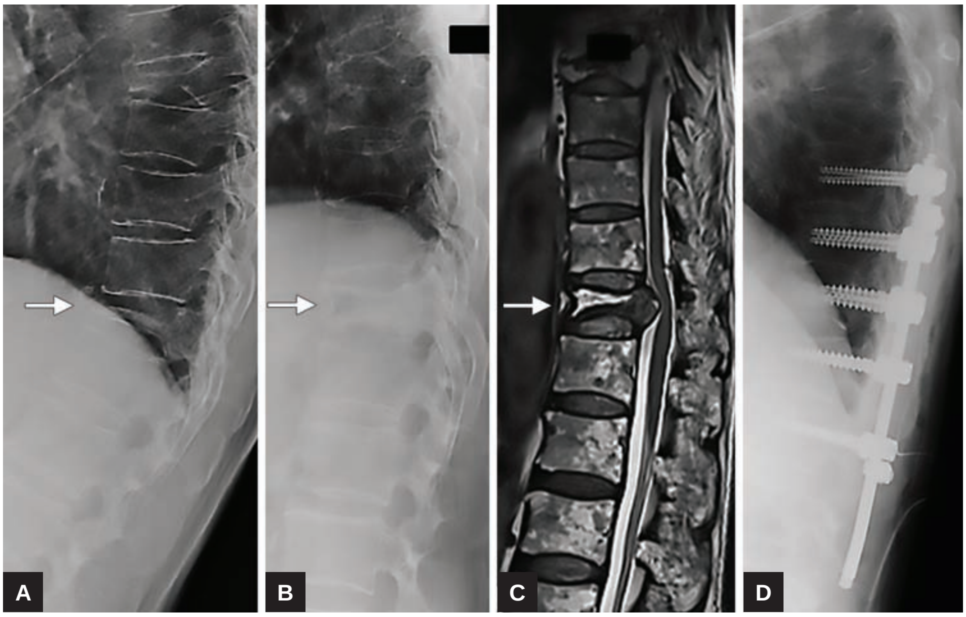
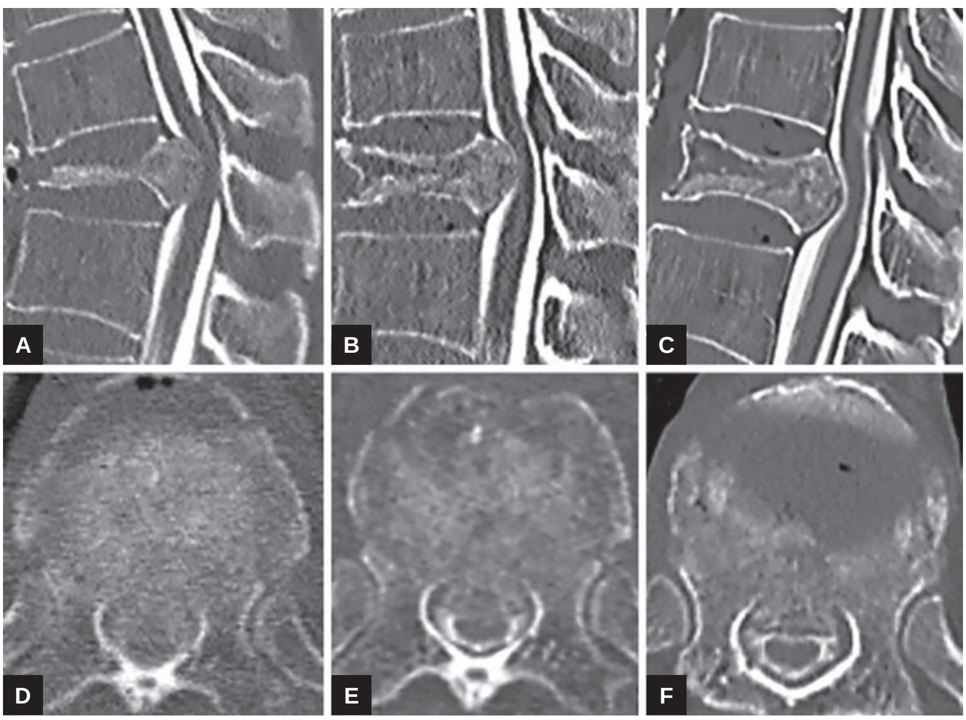
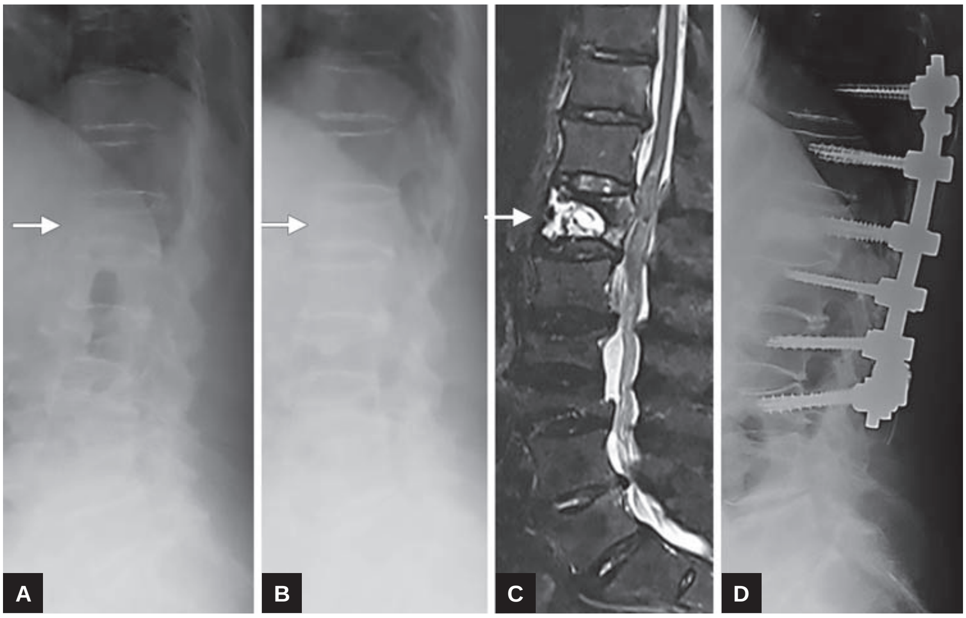


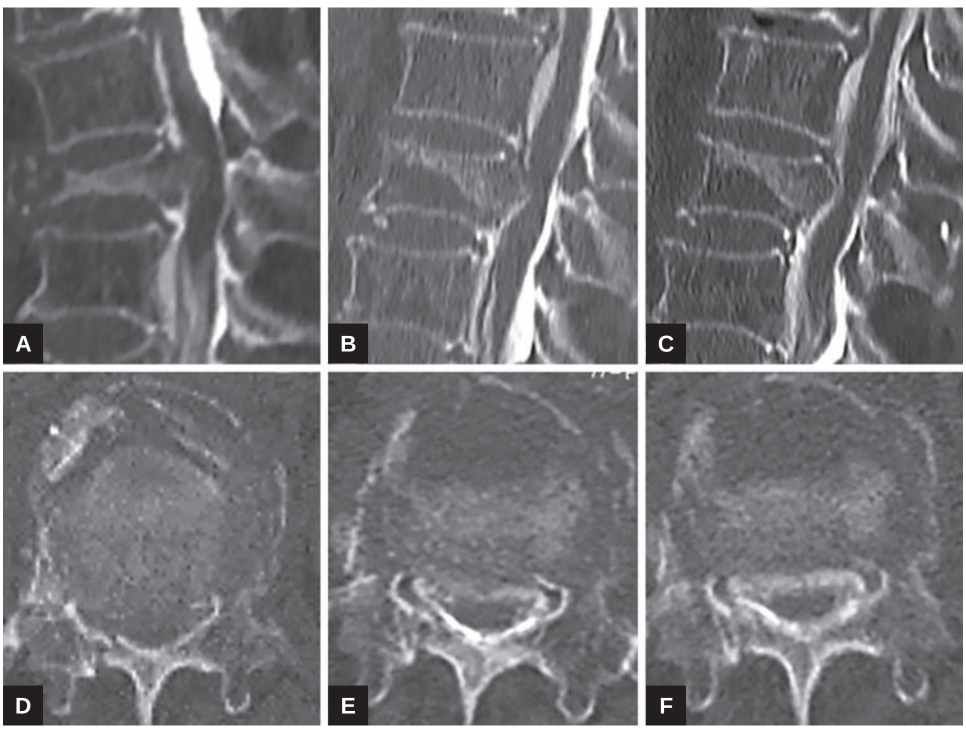
Fig 2A to D: Preoperative and postoperative images of Case 1 (an 87-year-old male). A plain X-ray showed that the body of the T11 vertebra was significantly collapsed when the patient was in the standing position but the collapse was reversed when the patient was in the supine position. Vertebral instability was significantly affected by the position of the body (A, B). A T2-weighted MRI showed a high intensity area where the collapsed posterior vertebral fragment significantly retropulsed into the spinal canal, firmly compressing the spinal cord (C). Posterior spinal fusion of T9 to L1 without decompression and vertebroplasty was performed on the T11 vertebra (D)



Figs 3A to F: Dynamic CTM of Case 1. Ratio of occupation by bony fragments of the spinal canal was calculated as the ratio in percentage of axial diameter of bony fragments to axial diameter of the spinal canal on axial CTM images.[10] Narrowing of the spinal canal due to bony fragment retropulsion was 64% in the semi-sitting position (A, D) and 56% in the supine position (B, E) but decreased to 39% in the prone position with the contrast medium flowing between the fragment and the spinal cord (C, F). Spinal decompression was considered unnecessary based on the CTM images



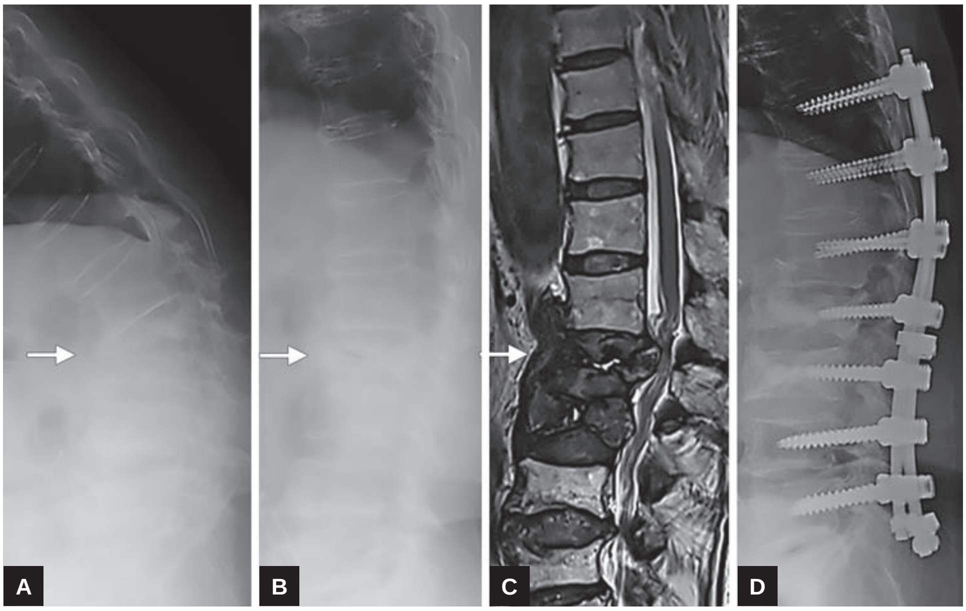
Figs 4A to D: Preoperative and postoperative images of Case 2 (an 87-year-old female). A plain X-ray in the lateral position showed she had a transitional vertebra and significant collapse of the body of the L1 vertebra. Vertebral instability was significant in flexion (A) and extension (B). A T2-weighted MRI showed a high intensity area in the L1 vertebral body where the collapsed posterior vertebral fragment significantly retropulsed into the spinal canal, firmly compressing the spinal cord to the back (C). Posterior spinal fusion of T11 to L4 without decompression and vertebroplasty was performed on the L1 vertebra (D)



Figs 5A to F: Dynamic CTM of Case 2. Narrowing of the spinal canal was 75% in the semi-sitting position (A, D) and 50% in the supine position (B, E) but decreased to 30% in the prone position, with the contrast medium flowing between the fragment and the spinal cord (C, F). Spinal decompression was considered unnecessary based on the CTM images

Case 3

A 78-year-old female patient with lower back pain after falling from a bicycle was diagnosed with OVF in the L2 and L3 vertebrae. She gradually became aware of weakness of the lower limbs and consulted us about 4 months after the injury. The muscle strength was rated MMT 1 for knee extension and MMT 4 for ankle dorsiflexion. A plain x-ray in the standing position (Fig. 6A)



Figs 6A to D: Preoperative and postoperative images of Case 3 (an 87-year-old female). A plain X-ray in the standing position (A) showed significant collapse of the body of the L2 vertebra, but the collapse was reversed in the supine position (B). The vertebral instability was significantly affected by the body position. MRI showed a fracture at the L2 and L3 vertebral bodies. The vertebral fragment of the posterior wall significantly retropulsed into the spinal canal, firmly compressing the cauda equina to the back of the L2 vertebra (C). Posterior spinal fusion of T11 to L5 with decompression at L2 and vertebroplasty was performed on the L2 and L3 (D)

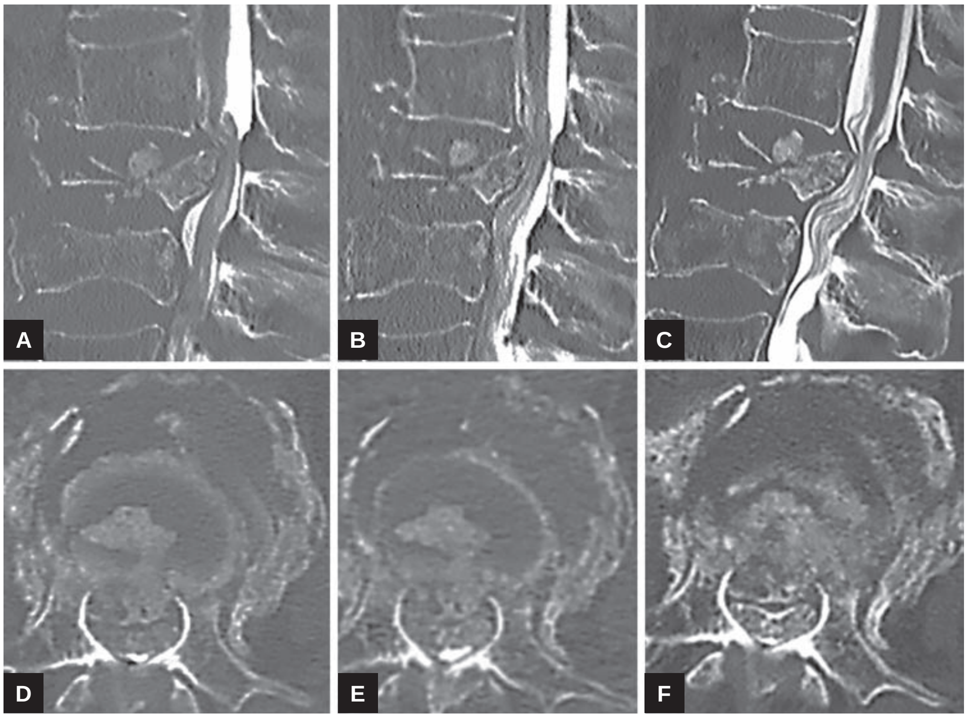
showed significant collapse of the body of the L2 vertebra, but the collapse was reversed in the supine position (Fig. 6B). The vertebral instability was significantly affected by the body position. The MRI showed a fracture at the L2 and L3 vertebral bodies. The vertebral fragment of the posterior wall significantly retropulsed into the spinal canal, firmly compressing the cauda equina to the back of the L2 vertebra (Fig. 6C). The spinal canal narrowing was 61% in the semisitting position (Figs 7A and D), 57% in the supine position (Figs 7B and E), and 56% in the prone position (Figs 7C and F). Decompression of the cauda equine during the surgery was considered necessary based on the CTM images. Posterior spinal fusion of T11 to L5 with decompression at L2 was performed using pedicle screws (ES2). Vertebroplasty with Regenos was performed on the L2 and L3 (Fig. 6D). The lower back pain disappeared after the surgery and the lower limb paralysis gradually improved.

DISCUSSION

Surgical time and blood loss should be minimized while performing necessary procedures during surgery with the patient in the prone position under general anesthesia to reduce perioperative complications, especially, in the elderly. The advantages of not requiring decompression of a compressed spinal cord and cauda equina include decreased surgical time and blood loss, large reduction in the risk of postoperative epidural hematoma, and preservation of posterior vertebral elements.

Ataka et al[8] and Katsumi et al[9] performed posterior instrumentation without decompression in patients with preoperative spinal canal narrowing <40% and reported good outcomes in all patients. On the contrary, Nguyen et al[6] performed decompression in all patients with a mean narrowing of 41%. According to Sudo et al,[10] decompression will be necessary in all patients except whose lower limb paralysis becomes milder in the supine position in principle. According to these previous reports using only supine-position imaging, whether decompression will be necessary, is therefore still controversial.

Based on supine-position CTM, the ratio of spinal canal occupation was over 40% in case 1 (56%) and case 2 (50%) among the three cases we presented in this report, and decompression would have been necessary according to the traditional criterion. However, the ratio of spinal occupation was less than 40% (39 and 30% respectively) in the prone position (surgical position) on CTM because of severe vertebral instability. Therefore, preoperatively, we determined that decompression was unnecessary. In case 3, the occupation of the spinal canal by fragment retropulsion seen on supine-position CTM (57%) essentially showed no change from that seen on prone-position CTM (56%) because the instability of the posterior vertebral fragment was minimal. Decompression was apparently necessary in this patient. The severity of intraoperative nerve compression cannot be estimated based on supine-position imaging alone because the degree of vertebral instability varies among patients, as in the three cases we presented in this report.



Figs 7A to F: Dynamic CTM of Case 3. Narrowing of the spinal canal was 61% in the semi-sitting position (A, D), 57% in the supine position (B, E), and 56% in the prone position (C, F). Decompression of the cauda equina during the surgery was considered necessary based on the CTM images

Prone-position MRI may be used for preoperative assessment. However, prone-position CT will be highly useful because it requires only a short time, is easy if the patient cooperates, causes less physical discomfort, and makes preoperative assessment more appropriate than MRI.

Although prone-position CTM is still in the trial stage and has been performed in only a small number of patients, we believe that it could be a reliable preoperative imaging method to appropriately estimate the necessity of decompression.

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