

ORIGINAL ARTICLE

Posterior spinal shortening for paraparesis following vertebral collapse due to osteoporosis

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Study design: Retrospective case series.

Objectives: To assess the efficacy of posterior spinal shortening for paraparetic patients following vertebral collapse owing to osteoporosis, especially on instrumentation loosening.

Setting: Department of orthopaedic surgery, Jichi Medical University Hospital and Omiya Medical Center in Japan.

Methods: The clinical records and radiographs of 13 patients with paraparesis following vertebral collapse owing to osteoporosis treated with posterior spinal shortening were retrospectively reviewed to evaluate the usefulness of this method. Assessment of the clinical course was done by direct examination in all cases. Ambulatory ability was divided into four categories.

Results: Upon final observation, nine cases were able to walk with a cane or crutch, one case remained in gait training, two cases remained unable to stand and one case with urinary incontinence improved in urinary function. In one case, paralysis deteriorated. Vertebral compression fracture of the end vertebrae that were fixed occurred in three cases complicated with rheumatoid arthritis.

Conclusion: The posterior spinal shortening can be a choice for treating delayed paraparesis following vertebral collapse owing to osteoporosis.

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Keywords: spinal shortening; paraparesis; vertebral collapse; osteoporosis

Introduction

Thoracolumbar compression fractures are extremely frequent in osteoporosis patients;^{1,2} in most cases, there is no impaired function and prognosis is good.³ Nonetheless, in some cases collapse progresses further in the course of 1–2 months. When this happens, local kyphotic deformation and fractures do not heal, that is, the patient suffers from vertebral pseudarthrosis. In such cases, intense back pain results from the instability at the site of pseudarthrosis, and the patient becomes unable to assume a sitting or standing position. Compression of the spinal cord is caused by the protruding vertebral posterior wall, and delayed myelopathy manifests. This pathology has relatively recently become widely known. In 1958, Kempinsky *et al.*⁴ reported two surgical cases. However, the pathology was not widely known and was only actively reported^{5–8} after it was reported by Maruo *et al.* in 1987.⁹

Once osteoporotic vertebral collapse induces the severe paraparesis, many patients do not respond to conservative

treatment and often require surgical treatment. However, this surgery is highly invasive for the extreme elderly, so prevention of perioperative and postoperative complications and a good prognosis are sought. In Kempinsky's⁴ cases, however, laminectomy was performed, although there was no effective improvement. Afterwards, improvement by laminectomy with spinal fusion surgery using instrumentation has been reported.⁹

When posterior instrumentation is used, the instrument cannot exhibit adequate retention force with respect to rarefied osteoporotic vertebrae, and frequently dislocation of screws, hooks, wires, etc. or fractures of the anchoring site occur, resulting in the recurrence of kyphosis.¹⁰ Posterior spinal instrumentation strength is strongest with the insertion of screws into the vertebral pedicle. However, strength is insufficient in rarefied osteoporotic vertebrae.¹¹ There are opinions that anterior surgery is reasonable,⁶ but the current authors addressed the condition by modifying posterior surgery using pedicle screws.¹²

Mechanism of instrumentation dislocation

The mechanism by which instrumentation dislocates is understood as follows.¹² The vertical load placed on a

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backward-curved thoracic spine acts to enhance thoracic kyphosis. In cases with a compression fracture in particular, kyphosis intensifies from the beginning and kyphosis-enhancing action increases the compression further. When posterior fusion is performed in these circumstances, the upper thoracic vertebrae escape anteriorly from the position at which they were fixed perioperatively owing to the force with which this kyphosis is enhanced. In addition, the curvature of internal fixation instruments is invariant, so the vertical load on the spine becomes the vector at which pedicle screws dislocate. Particularly when posterior fusion is performed as a part of correction, exerting force to reduce kyphosis by surgery, the possibility of pedicle screw dislocation increases. In that case, misalignment occurs between vertebrae and screws in serious cases of osteoporosis, resulting in dislocation.

Concept of posterior spinal shortening

We considered not the enhancement of binding between screws and vertebrae but rather the prevention of screw dislocation by manipulation of the vector at which screws dislocate.¹² In posterior spinal shortening as we propose it, the upper and lower spines are brought parallel by resecting and shortening posterior elements of a fractured vertebra to the same extent as anterior portions, allowing substantial reduction of kyphosis. Thus, thoracic spinal curvature nears straight, and the vector at which kyphosis is enhanced decreases even if the same load is placed on the thoracic spine (Figure 1). The result is that dislocation of screws will not readily occur. Wedging of vertebral bodies at the compression fracture site becomes marked and the biggest factor for enhancement of backward curvature, so shortening of the fractured posterior spine is extremely effective.

Materials and methods

The current research is a retrospective study of cases in which the authors performed surgery. This pathology occurs in the extreme elderly, so surgical indications are cases with

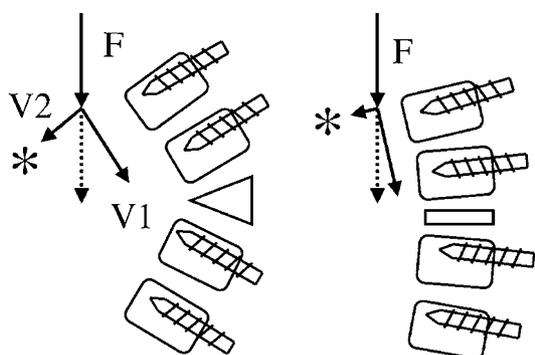


Figure 1 Concept of posterior spinal shortening. The magnitude of V2 decreases when the thoracic kyphosis is lessened (right). (F, vertical load to the thoracic spine; V1, vector in the axial direction; V2, vector that pushes the thoracic spine inferio-ventrally; permitted reprint from Saita *et al.*¹²).

obvious paraparesis as a result of spinal cord compression and do not include cases of pain alone. Radiographical indication is a thoracolumbar vertebral collapse above L1 and dynamic X-rays show apparent instability or an appearance and disappearance of vacuum cleft indicating pseudoarthrosis. In addition, we confirm the protrusion of a posterior wall of vertebral body in computed tomography (CT) and spinal cord compression in magnetic resonance imaging (MRI).

Patients

This method was performed on 13 cases (three men, 10 women) from October 1996 to April 2003. Age at the time of surgery ranged from 63 to 83 years, with an average of 75.2 years. Follow-up was from 6 to 71 months, with an average of 36.4 months, and cases with a follow-up of less than a year were cases that died because of unrelated disease. There were five cases with rheumatoid arthritis (RA) as an underlying disease, and steroids were used in all of the cases.

The preoperative severity of paralysis was inability to stand in 10 cases; two cases were able to stand while holding onto a bedside rail, but they were unable to walk; one case was able to walk but complained of severe urinary incontinence. The fracture site was T11 in two cases, T12 in six cases, and L1 in five cases. We performed CT and MRI and confirm the vertebral instability and spinal cord compression in all the cases.

Assessment of the clinical course was carried out by neurological examination and assessment of activities of daily living by direct examination in all cases. Ambulatory ability was divided into four stages of inability to stand, ability to stand while holding onto some aid, ability to walk with a cane or crutch, and ability to walk independently. In addition, lateral X-rays of the thoracolumbar junction were taken periodically, and the height of the fractured posterior spine, angle of kyphosis and screw loosening were observed. With regard to the angle of kyphosis, lines tangential to the upper and lower end plates of the fractured vertebra were drawn, and the angle formed by these two lines was measured.

Surgical procedure

The surgery is performed in a prone position. Two levels above and below the fractured vertebra should be exposed and up to the transverse process in the lateral direction. The lamina and caudal facet joints in the fractured vertebra are resected. After the cutting of the transverse processes, the outer cortex of the vertebral body is explored along the outer cortex of the pedicle. Thereafter the pedicle screws in the two vertebrae above and below are inserted.

The following procedures are performed with a contralateral rod setting. In the spinal canal, the fractured posterior cortex is osteotomized by a small chisel and the necrotized intravertebral cancellous bone is removed by small forceps with a gentle retraction of the dural tube (Figure 2a). In the lateral portion, the posterior cortex below the pedicle is resected with retracting the nerve root cephaladly. In some cases, the additional resection of the caudal part of the

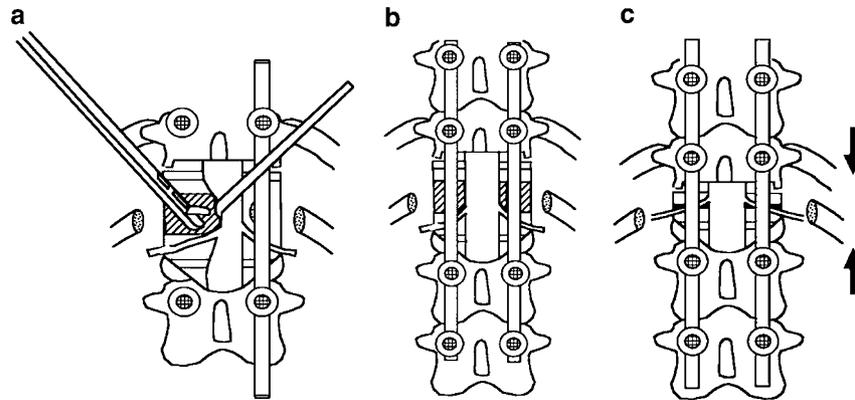


Figure 2 Surgical procedure. (a) Removal of the necrotized intra-vertebral cancellous bone. Because this is a figure for explanation, a dural tube is protected by a small spatula, and it is extremely slightly retracted actually. (b) Bilateral rods setting before spinal shortening. (c) Spinal shortening by application of compression force (permitted reprint from Saita *et al.*¹²).

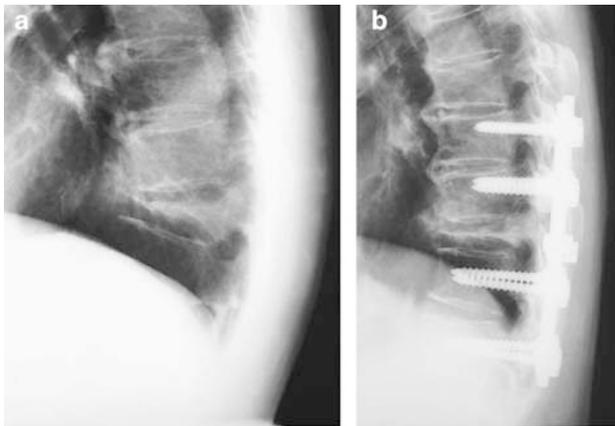


Figure 3 Case presentation: 74-year-old man. (a) The T11 vertebral body was collapsed. He could stand using a hand rail but not walk at all. (b) Thirty months after surgery. The T11 vertebra was shortened and instrumented from T9 to L1.

pedicle is necessary. The posterior part of the vertebral body becomes empty after these procedures, and then the thin end plates are left.

After the complete decompression of the spinal cord, two rods are set bilaterally (Figure 2b). Compression force is added to the screws along these rods until the two end plates come in contact with each other (Figure 2c). Shortening the posterior part of the spine produces a short vertebral body. As a result, the end plates become parallel and the thoracic kyphosis decreases. Additionally, posterolateral fusion is performed by using the resected spinous process and the laminae (Figure 3a and b).

Results

Short-term results

Time for surgery ranged from 220 to 340 min, with an average of 279 min. Perioperative bleeding ranged from 390 to 1850 g, with an average of 917 g; variation was substantial. Main sources of bleeding were outside the intervertebral

joint, the lateral wall of the vertebra, and epidural; epidural bleeding was particularly frequent. There was no massive bleeding from segmental arteries as was feared in the event of development.

X-rays from within 2 weeks before and after surgery were compared. There was substantial variation in the height of the vertebra before surgery, depending on the extent of preoperative posterior wall collapse. Vertebral height ranged from 12 to 31 mm before surgery, with an average of 21.5 ± 5.0 mm; after surgery, it ranged from 5 to 19 mm, with an average of 11.7 ± 4.8 mm. Shortening of vertebral height after surgery was an average of 9.8 ± 3.3 mm. The angle of kyphosis ranged from 3 to 34° before surgery, with an average of 14.4 ± 9.0 °; after surgery, it ranged from -6 to 13°, with an average of -0.2 ± 5.5 °. The amount of correction was from 6 to 27°, with an average of 14.5 ± 6.8 °.

Medium-term results

Ambulatory ability. Upon final observation, the two patients who were able to stand while holding onto some aid were able to walk with a cane or crutch. Seven of the 10 patients who were unable to stand were able to walk with a cane or crutch; one patient remained in gait training in parallel bars; two patients remained unable to stand; and one patient with severe urinary incontinence improved in urinary function (Figure 4).

Complications. No obvious general complications occurred. In one case, a posterior vertebral wall that remained protruded posteriorly during shortening due to the force of compression; spinal cord compression intensified, and paralysis deteriorated. The preoperative lower limbs strength was 3+ in manual muscle test (MMT) and deteriorated to 3 just after surgery. We considered the patient could not perform because of pain, however there was no improvement after pain relief. As the degree of deterioration was small, we expected spontaneous recovery for 3 weeks. However there was no improvement, we resected the protruding vertebral posterior wall via further surgery, although substantive improvement was not obtained.

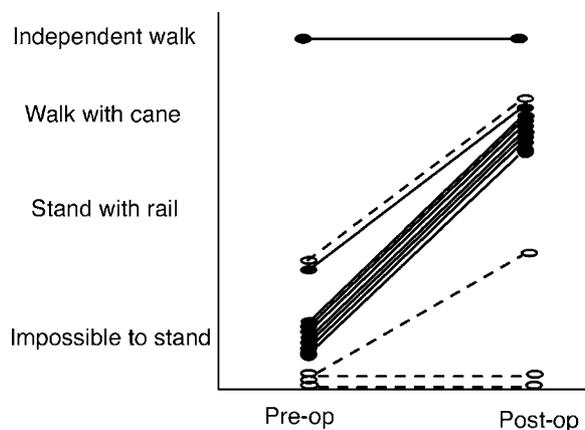


Figure 4 Surgical results. Eleven out of 13 cases were improved in activity (black dot: alive case. blank dot: dead case at final follow-up).

Vertebral compression fracture of the end vertebrae that were fixed occurred in three cases complicated with RA. Pedicle screw dislocation in the fractured vertebra occurred in two of these cases. In both cases, the subcutaneous layer bulged owing to displaced instrumentation. None of these were serious complaints. In addition, a vertebra adjacent to the fixation region was fractured in one of those cases. Gait training was continued with all three cases still fitted with a corset, and bone union occurred.

Excluding the two cases with obvious screw movement owing to a vertebral compression fracture and one case requiring additional surgery, the angle of kyphosis in 10 cases was corrected from 13.3 ± 7.8 to $-1.2 \pm 4.32^\circ$ and was $1.2 \pm 4.5^\circ$ upon final observation.

In 10 cases excluding two cases in which a fracture of the vertebra at the ends of fixation occurred and one case requiring further surgery, loosening at the caudal spine was observed in six cases.

Discussion

Investigating the relative merits of individual techniques^{5-9,12} that are considered to have good results in treating the current disorder is difficult. There are opinions recommending anterior surgery;⁶ this is based on the grounds that anterior surgery is reasonable because the cause of spinal cord compression exists anteriorly to the spinal cord and because breakdown of the spinal structure also exists in the front. However, one limitation of this approach is the large number of cases who cannot be treated by anterior surgery alone and with whom posterior techniques must also be used. In addition, anterior surgery requires thoracotomy and a retroperitoneal approach, and detachment of the diaphragm is also required in numerous instances where a fracture occurs at the thoracolumbar junction. Such a procedure is highly invasive for the extreme elderly. In addition, spine surgeons have few opportunities to experience anterior approach techniques.

In contrast, there are numerous opportunities to perform posterior approach techniques, and many spine surgeons are proficient at these procedures, so these techniques can be performed at many facilities. In addition, posterior compression such as ossified or hypertrophied yellow ligament is frequently combined, so this can be handled at the same time. Disadvantages of posterior techniques include the patient having to assume a prone position during surgery and the weak retention strength of internal fixation instruments. In addition, the substantial amount of perioperative bleeding and time required for instrumentation procedures remain disadvantageous.

There are several approaches to improving the retention strength of instruments lacking fixation strength with respect to osteoporotic bone. There are methods of increasing the strength of the bond between the vertebrae and screws by increasing the diameter of screws and coating screws with hydroxyapatite. In addition, there are also methods of filling the space between vertebrae with hydroxyapatite or bone cement.¹³⁻¹⁶ Even though these methods have displayed effectiveness experimentally, adequate results have not been reported clinically.

Thus, the current authors invented not the enhancement of binding between screws and vertebrae but rather the prevention of screw dislocation by manipulation of the vector at which screws dislocate. A similar procedure has been performed in ankylosing spondylitis or post-traumatic kyphosis, and excellent results have been reported without neurological deterioration.¹⁷⁻¹⁹ We adapted the posterior spinal shortening to control the direction of force applied to the implant by changing spinal curvature. When a fracture of the vertebra at the ends of fixation occurred, instruments were dislocated. Except for fractured cases, dislocation of instruments did not occur. Improvement in sagittal alignment through posterior spinal shortening was considered to be effective.

There was a neurologically deteriorated case. Thereafter, we confirm that the spinal cord is not compressed by posterior wall of vertebral body by careful direct vision, probing using small spatula and intra-operative eco imaging. There was no deteriorated case thereafter.

Postoperative fracture of adjacent vertebrae is challenging. Some medical therapy, for example, bisphosphonate may be effective and we actually used it. All the trouble cases were RA using steroid, so their bone quality were poorest. There are some reports of high incidence of early postoperative fracture of adjacent vertebrae after vertebroplasty. Existing surgical methods including ours have not overcome the poor bone quality.

The relationship between RA and the current condition is still unclear, although five of 13 cases the current authors' were cases of rheumatism, so there seems to be some causality. Advanced osteoporosis often occurs in cases of RA,²⁰ and cases of RA may account for a large proportion of osteoporosis cases in which further collapse occurs. Or collapse may readily occur in cases of RA, or collapse may readily occur in cases in which steroids are used. In any event, the truth is unknown. Instances where problems such as the fracture of a vertebra at the ends of fixation and

adjacent vertebrae occurred postoperatively were all cases of RA, so attention must be paid to the occurrence of complications for cases of RA.

Surgical techniques to treat osteoporotic vertebral compression fractures cannot be considered a closed issue. Spinal surgery is highly invasive for the extreme elderly and may at times occasion serious complications. After carefully considering factors like the patient's general condition, severity of osteoporosis, extent of paralysis, and extent of spinal cord compression, fully informed consent should be obtained and surgery performed. In addition, development of appropriate procedures and adequate study of surgical results are required for the future.

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