Korean J Neurotrauma. 2023 Jun;19(2):258-265
https://doi.org/10.13004/kjnt.2023.19.e21
pISSN 2234-8999·eISSN 2288-2243

KJNT

Case Report

Check for updates

Indirect Decompression of Osteoporotic Vertebral Compression Fracture Using Intraoperative Motor Evoked Potential Monitoring-Guided Ligamentotaxis

Subin Kweon, Saemin Kwon, Changhyun Kim, Changyoung Lee, Insoo Kim, and Young San Ko

Department of Neurosurgery, Keimyung University Dongsan Hospital, Daegu, Korea

OPEN ACCESS

Received: Feb 22, 2023
Revised: May 17, 2023
Accepted: May 18, 2023
Published online: Jun 16, 2023

Address for correspondence:
Young San Ko
Department of Neurosurgery, Keimyung University Dongsan Hospital, 1035 Dalgubeol-daero, Dalseo-gu, Daegu 42601, Korea.
Email: samkyu1@hotmail.com

ORCID iDs
Subin Kweon
https://orcid.org/0000-0002-1750-3961
Saemin Kwon
https://orcid.org/0000-0001-9720-6037
Changhyun Kim
https://orcid.org/0000-0001-5401-5660
Changyoung Lee
https://orcid.org/0000-0001-6046-2571
Insoo Kim
https://orcid.org/0000-0001-5569-7691
Young San Ko
https://orcid.org/0000-0002-6668-0905

ABSTRACT

Osteoporotic vertebral compression fractures have become common in aging societies and can lead to a decreased quality of life with severe back pain and neurological deficits. Traditional direct decompression and stabilization surgeries can produce sufficient decompression and provide good results. However, after surgical treatment, some elderly patients with numerous chronic diseases often experience severe postoperative complications owing to the long surgery duration and massive bleeding. Therefore, to prevent perioperative morbidity, other surgical methods that simplify the surgical process and reduce the operation time are required. Herein, we describe a case of indirect decompression using ligamentotaxis and sequential anabolic agents. To examine their effectiveness during surgery, we monitored intraoperative motor-evoked potentials. The patient's neurological symptoms improved postoperatively. After the operation, the anabolic agent "romosozumab" was injected monthly to treat osteoporosis, prevent additional fractures, and accelerate posterolateral fusion. On serial follow-up, the anterior body height of the fractured vertebra improved significantly, demonstrating the importance of osteoporosis treatment using anabolic agents. Indirect decompression surgery may have early effects, whereas sequential anabolic agent use may consolidate the long-term effects of surgical treatment.

Keywords: Osteoporotic fractures; Compression fracture; Anterior longitudinal ligament; Posterior longitudinal ligament; Fracture reduction; Evoked potential, motor; Anabolic agent

INTRODUCTION

With aging, osteoporosis has become common among the elderly.[16] The burden of osteoporotic vertebral compression fractures (OVCF) is increasing drastically due to an increasing incidence of aging-related osteoporosis and increased life span. OVCF causes severe back pain, kyphotic deformity, and neurologic deficits and can lead to decreased quality of life.[2,15] Due to the presence of geriatric-peculiar conditions and several comorbidities, surgical treatment is difficult in these patients.[4,6]

Conflict of Interest
The authors have no financial conflicts of interest.

Traditionally, the surgical treatment of OVCF with cord compression is direct decompression and posterior fixation, achieved by either the posterior approach or anterior and posterior combined.[11] However, direct decompressive surgery can cause serious postoperative complications due to the long operative time and massive blood loss,[5] which can endanger OVCF patients postoperatively. Therefore, we considered a method to simplify the surgical process and reduce the operation time. One of the methods is the indirect decompression technique that omits laminectomy and uses ligamentotaxis that is used for other joint fractures in orthopedic surgery.[12] However, it is uncertain whether indirect decompression is as effective as direct decompression surgery. Here, we describe a case of OVCF treated with an indirect decompression technique using ligamentotaxis.

CASE REPORT

A 69-year-old man with a history of stage IV non-small cell lung cancer (NSCLC) visited the emergency department with gradually worsening back pain and bilateral leg weakness (grade 3, manual muscle testing) for 2 months, accompanied by urinary incontinence. The visual analogue scale (VAS) score was 8 for the back pain, and he could not walk due to leg weakness. Neurologic examination revealed weak left great toe dorsiflexion (grade 3) without pain. Thoracic spine radiography, computed tomography (CT), magnetic resonance imaging (MRI), and dual-energy X-ray absorptiometry revealed a compression fracture of the 7th and 8th thoracic vertebrae. The compression rates of the vertebral bodies[1] were 71% (T7) and 30% (T8). T2-weighted MRI showed prominent cord compression with a high signal change in the spinal cord at the T7 level. Sagittal T2-weighted MRI showed continuity in the low signal of the anterior longitudinal ligament (ALL) and posterior longitudinal ligament (PLL) without any disconnection (**FIGURE 1**), which confirmed that the ALL and PLL were intact, justifying the use of indirect decompression via ligamentotaxis.[7,13]

Low bone mineral density with a T-score of −2.8, a prominent fracture line in the CT scan, and absence of paravertebral soft tissue invasion suggested a higher probability of

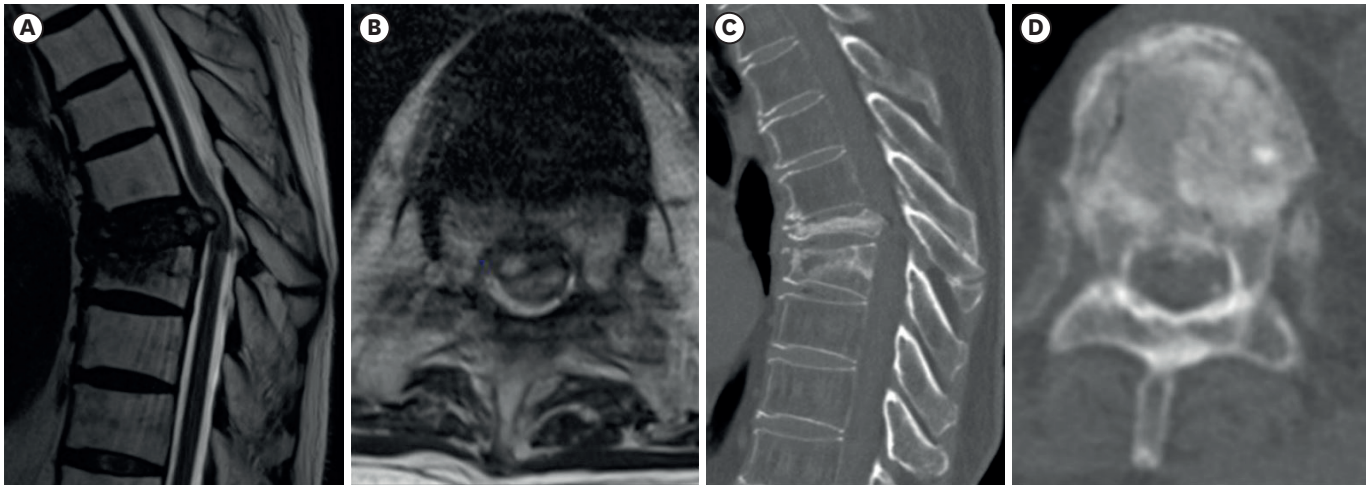

FIGURE 1. MRI and CT images of the patient. (A) Sagittal T2-weighted MRI showing the continuity of low signal of ALL and PLL without disconnection. (B) Axial T2-weighted MRI showing a cord compression lesion on thoracic 7th level. (C, D) CT showing no definite osteolytic lesion.
MRI: magnetic resonance imaging, ALL: anterior longitudinal ligament, PLL: posterior longitudinal ligament, CT: computed tomography.

https://doi.org/10.13004/kjnt.2023.19.e21

osteoporotic compression fracture despite the absence of a clear trauma history. However, the possibility of pathologic fracture was considered due to the history of stage IV NSCLC.

Surgical decompression and stabilization were required because of prominent cord compression and persistently progressing myelopathy. Considering the median survival of 8–10 months for stage 4 NSCLC and comorbidities of atrial fibrillation and chronic obstructive pulmonary disease, we decided to minimize the estimated blood loss and operation time to prevent perioperative morbidity.

The operation was performed under general anesthesia, with the patient lying prone on a radiolucent operating table. Motor evoked potentials (MEPs) were generated using transcranial electrical stimulation and were recorded from the tibialis anterior and abductor hallucis bilaterally. We initially attempted open posterior screw fixation and indirect decompression by distraction using ligamentotaxis. After inserting pedicle screws at T4–6 and T8–10, the operator distracted the pedicle screw between the T6 and T8 vertebrae using a distractor under fluoroscopic guidance (**FIGURE 2**). This force was directed along the long axis of the spinal column. As the vertebral bodies were gradually distracted, the soft tissue and ligament that surround the spinal column were also gently stretched. This tension helped to realign the displaced vertebrae and restore the natural curvature of thoracic spine (**FIGURE 2**). Interestingly, the anterior vertebral body height of T7 increased from 6.5 to 11 mm in the intraoperative fluoroscopy and the MEP waveform of the abductor hallucis muscle, which did not exist before, appeared and showed amplification indicating that meaningful indirect decompression had been achieved (**FIGURE 3**). Therefore, additional direct decompression

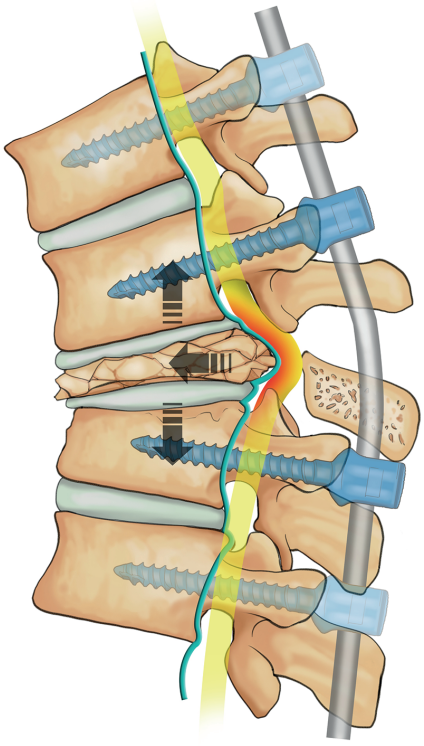

FIGURE 2. Illustration of ligamentotaxis.
Illustration showing ligamentotaxis that posterior longitudinal ligament pull fracture fragments back into place near the midline, while continuity of the anterior longitudinal ligament ensures that overdistraction does not occur.

https://doi.org/10.13004/kjnt.2023.19.e21

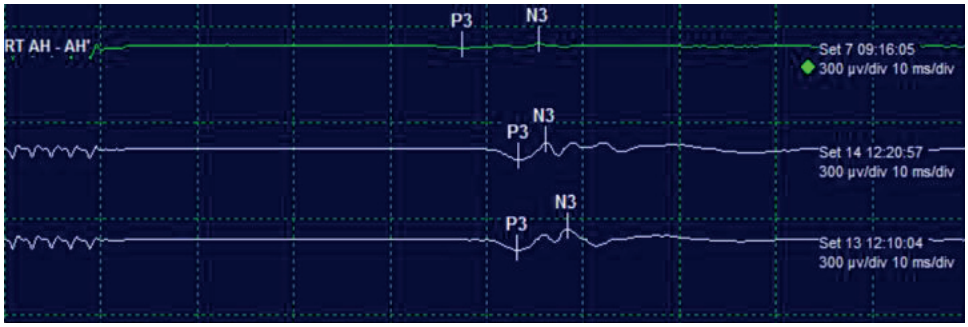

FIGURE 3. Image of Intraoperative neuromonitoring.
Intraoperative motor evoked potential showing a waveform of abductor hallucis muscle that did not exist before. It occurred and was amplified.

was not attempted to minimize additional blood loss and operation time. For successful posterolateral fusion, we removed partial cortical bone of each facet and transverse process, using drill and created a better surface for the fusion material to adhere to. When conducting decortication, autobone was collected through a mini-suction bottle, and was used with bone chip of allograft as fusion material, not bone morphogenetic proteins (BMPs) or demineralized bone matrix (DBM). We checked the segmental cobb angle from T4 to T10 (24°) through the pre-existing patient chest CT before the disease and adjusted the rod contour to that angle. After performing a transpedicular vertebral body biopsy to rule out pathologic fracture and posterolateral fusion at T4–10, the operation was finished. The estimated blood loss was 250 mL, and operation time was 3 hours.

Postoperatively, leg weakness improved to manual muscle testing grade 4, and the VAS score for back pain decreased from 8 to 4. The patient was braced by a thoracolumbosacral orthosis and was able to ambulate with a walker. Considering the history of lung cancer, we used the anabolic agent romosozumab monthly to treat osteoporosis to prevent additional fractures and accelerate posterolateral fusion. He was discharged on postoperative day 8 without any complications. At 1 month postoperatively, follow-up X-ray imaging showed an improvement in the T7 vertebral body height and kyphotic angle, although a new T10 compression fracture was seen. Additional kyphoplasty or screw extension was not performed because the patient was asymptomatic. Follow-up radiography at 21 months postoperatively showed no fracture progression (**FIGURE 4**). Additionally, further improvement in the segmental kyphotic angle was observed (**FIGURE 4**). At 21 months postoperatively, the VAS score was 3 for the back pain, and he could walk by himself using a cane. Instrumentation was well-maintained for up to 21 months without change in the patient's condition.

The segmental kyphotic Cobb angles were 38° and 24°, preoperatively and at 21 months postoperatively, respectively (**FIGURE 5**).[10] Anterior vertebral body height measurements of the T7 vertebra were 6.5 mm and 13.4 mm, preoperatively and at 21 months postoperatively, respectively, demonstrating that fusion was well done without additional compression (**FIGURE 5**).

Written informed consent was obtained to publish this report from the patient. The study has been approved by the Institutional Review Board (IRB) of the Keimyung University Dongsan Hospital, and the approved IRB number is 2022-5-076.

https://doi.org/10.13004/kjnt.2023.19.e21

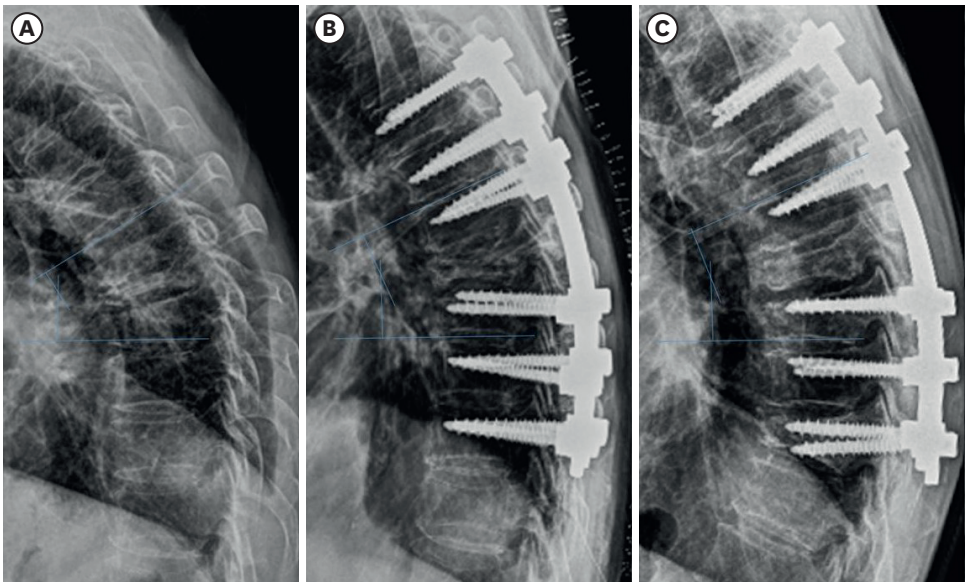

FIGURE 4. Postoperative X-ray images.
X-rays at (A) preoperatively, (B) postoperatively, and (C) 21 months postoperatively, respectively, that explain the improvement of the segmental kyphotic Cobb angle.

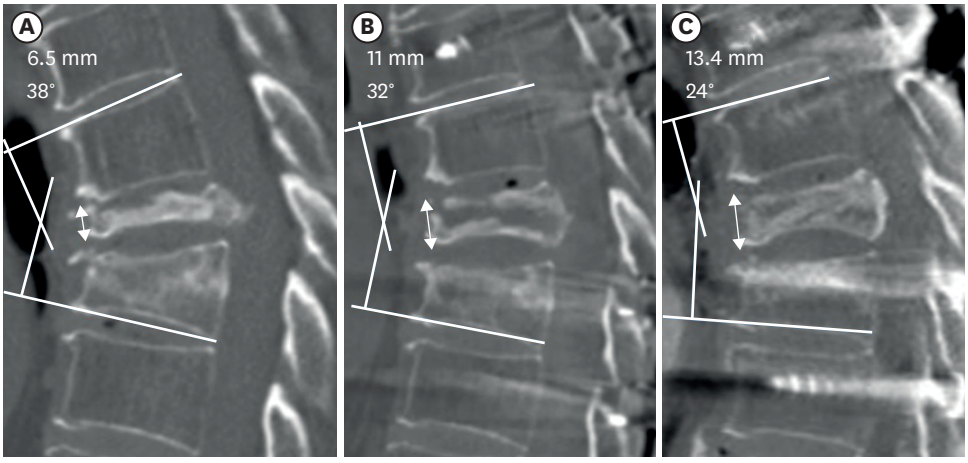

FIGURE 5. Postoperative computed tomography images.
Computed tomographys at (A) preoperatively, (B) postoperatively, and (C) 21 months postoperatively, respectively, that explain the improvement of the segmental kyphotic Cobb angle and Anterior vertebral height.

DISCUSSION

Surgical modalities for OVCF with neurological deficits include the posterior, or anterior and posterior combined approach,[11] which have been reported to successfully improve neurological deficits. However, implant-related complications and pseudoarthrosis occur in some patients due to poor bone quality.[5,9] The combined approach has a good fusion rate with both short- and long-term kyphosis angle correction.[14] Recent studies have also reported successful posterior closing wedge osteotomy, including posterior spinal shortening, which was performed for both neural decompression and correction of kyphotic deformity.[17] However, these surgical options are associated with increased morbidity due to the longer operative time and greater blood loss along with elevated risk of neural tissue damage and dural tear.[1] Moreover, a long duration of general anesthesia affects

https://doi.org/10.13004/kjnt.2023.19.e21

cardiopulmonary performance and aggravates pre-existing cardiac and pulmonary disease in elderly patients.[18] Therefore, a less invasive and effective treatment is required for OVCF with neurological deficits.

Indirect decompression using ligamentotaxis

Ligamentotaxis is an orthopedic method of molding fracture fragments into alignment by applying tension across a fracture using the surrounding intact soft tissues.[12] In the spine, when the PLL is intact, fragments near the midline are pulled back into place, while continuity of the ALL ensures that overdistraction does not occur.[12] This method can also be used in patients with OVCF in whom the ALL and PLL are intact.[4] This can be confirmed by MRI.[7] Furthermore, since most OVCF patients often have no history of trauma, the ALL and PLL of these patients are intact. Therefore, this method can be used in most OVCF patients. Indirect decompression with ligamentotaxis can reduce operation time, blood loss, and operative morbidity. Potential damage to the neural tissue during direct decompressive surgery can also be avoided. Moreover, the posterior midline elements of the spine, which are important for maintaining stability, can be preserved.

Use of intraoperative monitoring guidance

Intraoperative neuromonitoring (IOM) is sensitive and specific for detecting intraoperative neurological injury during spine surgery.[8] It is recommended that IOM should be used in spine surgery where the spinal cord or nerve roots are at risk, including procedures that involve instrumentation of the spinal cord injury and deformity correction. The most frequently used modalities for spinal procedures are somatosensory evoked potentials, MEPs, spontaneous electromyography, and triggered electromyography. Many studies have supported the application of distal muscle-recorded MEPs to predict the occurrence and severity of postoperative motor deficits during spinal surgery.[8] The likelihood of obtaining lower-limb MEPs is significantly higher in patients with better functional grades and higher motor power. We used MEP to confirm whether indirect decompression was effective. In this case, there was a meaningful change in MEP, and intraoperative radiography revealed kyphosis correction and an increase in the height of the anterior vertebral body. Consequently, we did not attempt additional direct decompression surgery in the form of laminectomy and resection of the anterior or posterolateral component. All symptoms were improved after surgery. Therefore, IOM can be used to estimate the effect of indirect decompression and as evidence for terminating the operation without additional decompression. However, if there is no meaningful change in IOM, the effect of indirect decompression using ligamentotaxis needs to be confirmed by intraoperative imaging, such as fluoroscopy and CT.

Use of anabolic agents after surgery

Osteoporosis can lead to bone fragility and fractures, resulting in increased clinical burden and mortality.[15] Anabolic agents improve bone mass and decrease fracture risk in osteoporosis patients by directly stimulating the osteoblasts to produce new bone. Romosozumab is a monoclonal antibody that binds and inhibits sclerostin, with the dual effect of increasing bone formation and decreasing bone resorption.[3] Considering the patient's history of lung cancer, we administered romosozumab monthly to our patient to treat osteoporosis and increased the chance of posterolateral fusion after indirect decompression using ligamentotaxis. In our case, successful posterolateral fusion was done without further compression (**FIGURE 5**). It was osteoporotic bone with poor bone mineral density, but it seems to have achieved a successful fusion using anabolic agent on it without damaging the spinal posterior column.

https://doi.org/10.13004/kjnt.2023.19.e21

Limitations

In some patients, this method cannot be applied due to its limitations. First, in severe osteoporosis, the anchoring effect that holds the screw in place is decreased, and the probability of screw failure is high when using this distraction method. Second, anabolic agents are costly and cannot be administered to all patients. Finally, if improvement by neuromonitoring is not confirmed, intraoperative imaging may be required to make sure that decompression has been properly performed. If there is no change even when using intraoperative imaging, direct decompression surgery should be considered for surgical salvage.

CONCLUSION

Indirect decompression surgery using ligamentotaxis under IOM in elderly patients with comorbidities is a less invasive and effective surgical option for patients with OVCF. In our patients, the effectiveness of indirect decompression surgery using ligamentotaxis was proven through intraoperative MEP monitoring. Additionally, using an anabolic agent resulted in a successful posterolateral fusion. Consequently, indirect decompression surgery might have early effects, while sequential anabolic agent usage may consolidate the surgical treatment with long-term effects.

REFERENCES

1. Aebi M, Etter C, Kehl T, Thalgott J. Stabilization of the lower thoracic and lumbar spine with the internal spinal skeletal fixation system. Indications, techniques, and first results of treatment. **Spine (Phila Pa 1976)** 12:544-551, 1987
PUBMED | CROSSREF
2. Baba H, Maezawa Y, Kamitani K, Furusawa N, Imura S, Tomita K. Osteoporotic vertebral collapse with late neurological complications. **Paraplegia** 33:281-289, 1995
PUBMED | CROSSREF
3. Bandeira L, Lewiecki EM, Bilezikian JP. Romosozumab for the treatment of osteoporosis. **Expert Opin Biol Ther** 17:255-263, 2017
PUBMED | CROSSREF
4. Borkar Santosh S,, Konde Shivraj S,, Kulkarni Priya Y,, Borkar Sumita S. Efficacy of ligamentotaxis of the intact and ruptured posterior longitudinal ligament in dorso-lumbar traumatic spine injuries. **Int J Med Res Prof** 2:98-102, 2016
CROSSREF
5. Chotigavanich C, Sanpakit S, Wantthanaapisith T, Thanapipatsiri S, Chotigavanich C. The surgical treatment of the osteoporotic vertebral compression fracture in the elderly patients with the spinal instrumentation. **J Med Assoc Thai** 92 Suppl5:S109-S115, 2009
PUBMED
6. Del Guercio LR, Cohn JD. Monitoring operative risk in the elderly. **JAMA** 243:1350-1355, 1980
PUBMED | CROSSREF
7. Emery SE, Pathria MN, Wilber RG, Masaryk T, Bohlman HH. Magnetic resonance imaging of posttraumatic spinal ligament injury. **J Spinal Disord** 2:229-233, 1989
PUBMED | CROSSREF
8. Gonzalez AA, Jeyanandarajan D, Hansen C, Zada G, Hsieh PC. Intraoperative neurophysiological monitoring during spine surgery: a review. **Neurosurg Focus** 27:E6, 2009
PUBMED | CROSSREF
9. Hakalo J, Wroński J. Complications of a transpedicular stabilization of thoraco-lumbar burst fractures. **Neurol Neurochir Pol** 40:134-139, 2006
PUBMED
10. NIH Consensus Development Panel on Osteoporosis Prevention, Diagnosis, and Therapy. Osteoporosis prevention, diagnosis, and therapy. **JAMA** 285:785-795, 2001
PUBMED | CROSSREF

https://doi.org/10.13004/kjnt.2023.19.e21

11. Hong JT, Lee SW, Son BC, Sung JH, Park CK, Kim MC. Kyphotic angle measurement accuracy for vertebral osteoporotic compression fracture: reliable method for kyphotic angle measurement. **J Korean Neurosurg Soc** 39:256-259, 2006
12. Kim DH, Vaccaro AR. Osteoporotic compression fractures of the spine; current options and considerations for treatment. **Spine J** 6:479-487, 2006
PUBMED | CROSSREF
13. Kuner EH, Kuner A, Schlickewei W, Mullaji AB. Ligamentotaxis with an internal spinal fixator for thoracolumbar fractures. **J Bone Joint Surg Br** 76:107-112, 1994
PUBMED | CROSSREF
14. Lee HM, Kim HS, Kim DJ, Suk KS, Park JO, Kim NH. Reliability of magnetic resonance imaging in detecting posterior ligament complex injury in thoracolumbar spinal fractures. **Spine (Phila Pa 1976)** 25:2079-2084, 2000
PUBMED | CROSSREF
15. Nakashima H, Imagama S, Yukawa Y, Kanemura T, Kamiya M, Deguchi M, et al. Comparative study of 2 surgical procedures for osteoporotic delayed vertebral collapse: anterior and posterior combined surgery versus posterior spinal fusion with vertebroplasty. **Spine (Phila Pa 1976)** 40:E120-E126, 2015
PUBMED | CROSSREF
16. Reginster JY, Burlet N. Osteoporosis: a still increasing prevalence. **Bone** 38:S4-S9, 2006
PUBMED | CROSSREF
17. Suk SI, Kim JH, Lee SM, Chung ER, Lee JH. Anterior-posterior surgery versus posterior closing wedge osteotomy in posttraumatic kyphosis with neurologic compromised osteoporotic fracture. **Spine (Phila Pa 1976)** 28:2170-2175, 2003
PUBMED | CROSSREF
18. Wang S, Yang Y, Li Q, Zhu J, Shen J, Tian Y, et al. High-risk surgical maneuvers for impending true-positive intraoperative neurologic monitoring alerts: Experience in 3139 consecutive spine surgeries. **World Neurosurg** 115:e738-e747, 2018
PUBMED | CROSSREF

https://doi.org/10.13004/kjnt.2023.19.e21