

Original Article

Transpedicular wedge osteotomy for treatment of kyphosis after L1 fracture using intraoperative, full rotation, three-dimensional image (O-arm)-based navigation: a case report

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Abstract: There has been a large series in the literature reporting on results of osteotomy for the correction of kyphotic deformity secondary to post-traumatic thoracolumbar fracture. However, there are few reports on using intraoperative, full rotation, three dimensional image (O-arm)-based navigation, transpedicular wedge osteotomy for the correction of kyphotic deformity in old thoracolumbar fracture. A 45-year-old woman with L1 old fracture, presented to us with a Cobb angle of 45 degrees. The preoperative standard anteroposterior, lateral views and computed tomography (CT) reconstructions revealed kyphotic deformity. After attaching the reference arc of the 3D-imaging system, the thoracolumbar spine was screened using an O-arm without anatomical registration. The location, angle and depth of osteotomy, as well as screw fixation were performed using a guide tube while referring to the reconstructed 3D-anatomical views. The surgery was successful without nervous and vascular injuries. Using intraoperative, full rotation, three dimensional image (O-arm)-based navigation, the transpedicular wedge osteotomy is a safe and effective treatment for kyphosis after the thoracolumbar fracture, which can insert the pedicular screw accurately, trace the real-time wedge osteotomy and reduce the loss of correction of kyphotic deformity.

Keywords: Thoracolumbar fracture, kyphotic deformity, transpedicular wedge osteotomy, three-dimensional image-based navigation

Introduction

The post-traumatic thoracolumbar fracture can lead to spinal kyphotic deformity in the late stages. Because of the overall loss of sagittal balance, patients suffer from back pain and cosmetic which could interfere with personal hygiene and daily physical life. Recently, pedicle subtraction technique has gained popularity because they achieve a reliable one-stage correction [1, 2]. However, this approach is postulated as technically demanding and is performed within the vertebral column. Some authors also complain about the difficulty in obtaining the accurate location, angle and depth of osteotomy. Moreover, pedicle screw fixation of thoracic spine remains challenging because of the associate risk to neurovascular structures. It may cause the loss of correction

of kyphotic deformity. In order to reduce the potential complications, Three-dimensional (3D) image-based navigation may be advantageous because it can insert the pedicular screw accurately, trace the real-time wedge osteotomy. In this article, we present a case of osteotomy for the correction of kyphotic deformity secondary to post-traumatic thoracolumbar fracture using intraoperative, full rotation, 3D image (O-arm)-based navigation.

Case report

A 45-year-old woman with kyphotic deformity was presented to our hospital with thoracolumbar back pain after a minor fall. Twenty-five years ago, the patient fell down accidentally when she was working. Initial plain radiographs were not made and there were no special treat-

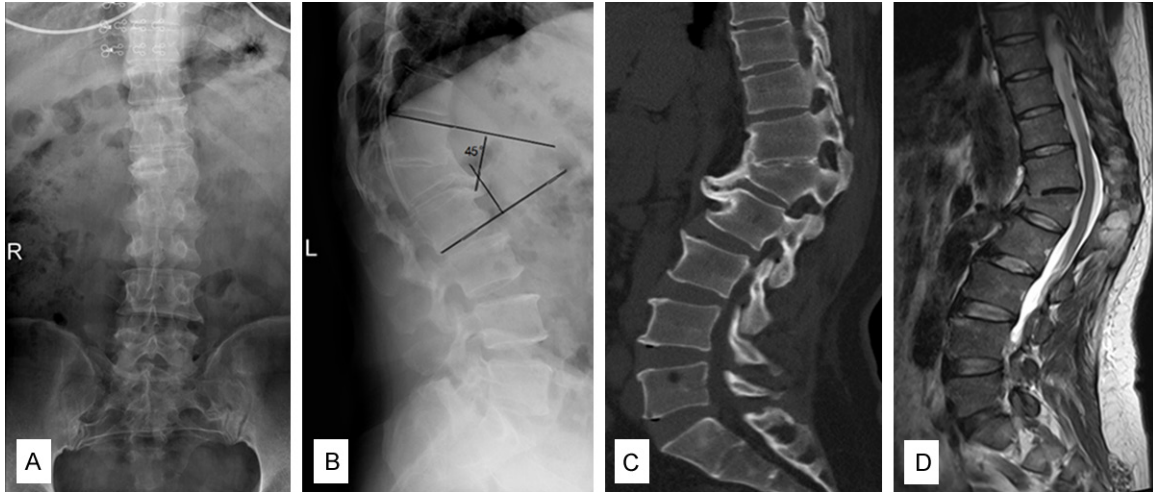


Figure 1. The pre-operative anteroposterior (A) and lateral (B) radiographs showed thoracolumbar kyphosis with a 45° Cobb's angle. Pre-operative computed tomography (CT) scan reconstructions (C) showed L1 old fracture and kyphotic deformity of L1 vertebrae. Pre-operative sagittal T2-weighted magnetic resonance image (D) revealed the absence of spinal cord compression.

ment for her. She developed progressive thoracolumbar back pain gradually. The standard anteroposterior, lateral views and computed tomography (CT) reconstructions showed a classical appearance of kyphosis with a compression fracture of L1. The corresponding Cobb angle of the kyphotic deformity was about 45 degrees (**Figure 1B**). Magnetic resonance imaging revealed the absence of spinal cord compression (**Figure 1D**). The lesion was recognized as kyphosis with L1 old fracture and we tried to perform transpedicular wedge osteotomy for her with intraoperative, full rotation, three dimensional image (O-arm)-based navigation.

Surgical technique

Fiberoptic intubation preceded the induction of general anesthesia. The patient was placed prone on a Jackson radiolucent table and sterilely prepped and draped. The spine was approached by a posterior midline exposure with dissection laterally to the transverse process. The reference arc was placed on the spinous process. The O-arm was used to obtain an intraoperative CT scan, which was automatically registered to the image guidance system. The image-guided probe was used to ascertain the trajectory of pedicle screw, location and angle of osteotomy (**Figure 2A**). With the image-guided, transpedicular screws were inserted in the T11, T12, L2 and L3 to ensure stability and

consolidation. The L1 vertebral spinal process and its adjacent supraspinal and interspinal ligaments with the connected transverse processes were resected. The vertebral plates and the nerve roots from the segment above and below the disk were exposed and fully decompressed to prevent the spinal cord or nerve roots from compression when osteotomy surface was closed. Under image guidance with the navigated instruments, all the lamina was resected and the pedicle was excised with a rongeur and an a V-shaped cut was performed from the lateral cortex to the midline including all the base of the pedicle, and ending just posteriorly to the anterior cortex of the vertebral body. The pre-bending rod was to correct deformity and fixed the spine under inspects the osteotomy site and neural elements. The bone from the osteotomy was used as a graft placing it posterior-laterally next to the osteotomy site. The final correction of deformity and position of the screws were confirmed by an image intensifier in lateral and anteroposterior view. Routine closure was carried out and drains were left in place as needed for 24-48 hours. The patient was asked to sit up three days later and walked with orthosis after ten days.

Discussion

Spinal trauma may lead to an increased kyphotic deformity, which could make patients have difficult in sitting, standing, or lying. With pro-

Transpedicular wedge osteotomy for kyphosis

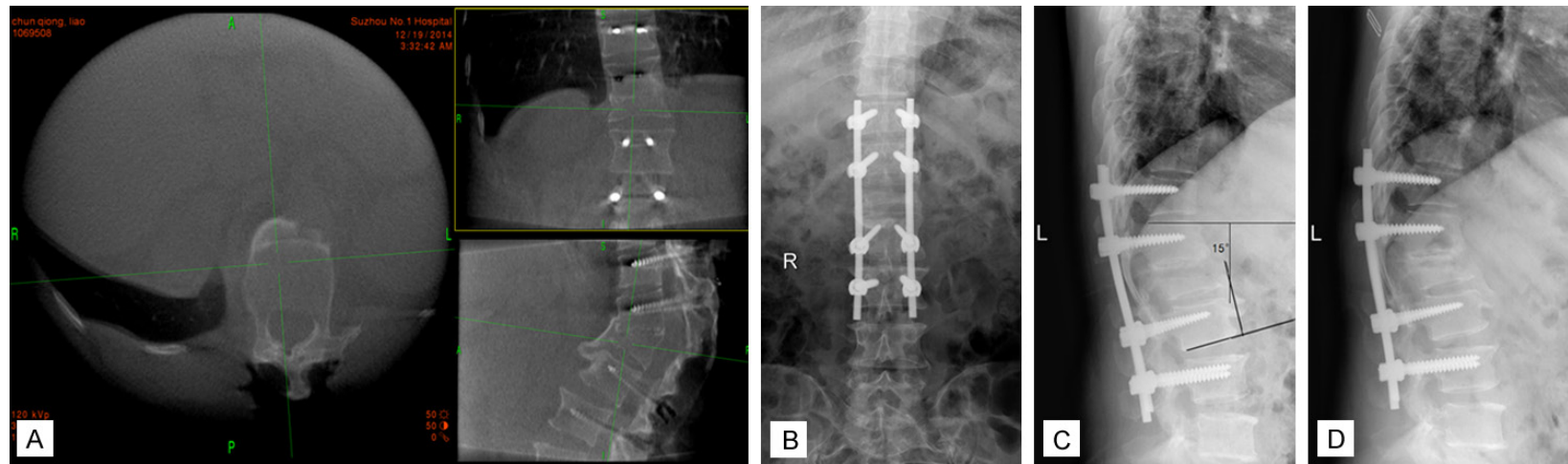


Figure 2. The image-guided three-dimensional image (A) ascertained the trajectory of pedicle screw, assessment site and magnitude of osteotomy. Post-operative anteroposterior (B) and lateral (C) radiographs showed a 15° Cobb's angle. The lateral radiographs (D) of 6-month follow-up showed no loss of correction.

gression of the deformities, the indication for surgery may be considered absolute [3, 4]. The surgery for this kind of patients is to improve the appearance, retrieve horizontal visual field, rebuild sagittal balance and relieve back pain [5, 6]. Several operative techniques may be used to correct the kyphosis. Transpedicular wedge osteotomy for correction of kyphosis caused by post-traumatic thoracolumbar fracture is one of the commonly used surgical techniques. It corrects the deformity by shortening the posterior column. Thus correction may be achieved regardless of disc status and curve rigidity. In addition, it can be performed even if there are bridging syndesmophytes. However, Free hand or conventional fluoroscopy-based osteotomy is associated with several disadvantages. First, it is difficult to obtain the accurate location, angle and depth of osteotomy, because transpedicular wedge osteotomy is performed in the pedicle with a high-speed drill. The second concern to the extent of osteotomy is sometimes judged insufficient, which may cause the loss of correction of kyphotic deformity. In addition, the relatively narrow thoracic spinal canal renders the midthoracic spinal cord more vulnerable to perioperative injury. Therefore, we try to perform transpedicular wedge osteotomy with using intraoperative, full rotation, three dimensional image (O-arm)-based navigation. To our knowledge, there no reports describing a transpedicular wedge osteotomy with 3D image guidance.

The O-arm Surgical Imaging System provides high-definition 3D, multiplane fluoroscopic images that can be automatically registered to a stealth neuronavigation station in a time-efficient process. Real-time feedback of the osteotomy in the axial, sagittal, and coronal planes can be achieved by intraoperative 3D navigation. It has been shown to result in accurate intraoperative assessment site and magnitude of osteotomy, which is effective in estimating how much correction is necessary to result in a balanced upright position. Besides, it has a low rate of secondary loss of correction probably due to the nature of the osteotomy where the two cancellous surfaces interact with a rapid healing. Furthermore, the width of the pedicle and depth of the screw tract could be measured using the navigation system to allow screw diameter and length to be custom fit to each pedicle [7, 8]. Customizing the screw size

optimizes the fixation and reduces the risk of nervous and vascular injuries [7-10]. The patient in our study regained satisfactory functional outcome with no neurovascular injury. The postoperative standard lateral view showed the Cobb angle of 15 degrees (**Figure 2C**) and she obtained excellent fusion and good stability without loss of correction at the final follow up.

In conclusion, using intraoperative, full rotation, three dimensional image (O-arm)-based navigation, the transpedicular wedge osteotomy is a safe and effective treatment for kyphosis after the thoracolumbar fracture, which can insert the pedicular screw accurately, trace the real-time wedge osteotomy and reduce the loss of correction of kyphotic deformity.

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Disclosure of conflict of interest

None.

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References

- [1] Kawahara N, Tomita K, Baba H, Kobayashi T, Fujita T, Murakami H. Closing-opening wedge osteotomy to correct angular kyphotic deformity by a single posterior approach. *Spine (Phila Pa 1976)* 2001; 26: 391-402.
- [2] Danisa OA, Turner D, Richardson WJ. Surgical correction of lumbar kyphotic deformity: posterior reduction "eggshell" osteotomy. *J Neurosurg* 2000; 92 Suppl 1: 50-56.
- [3] Goel MK. Vertebral osteotomy for correction of fixed flexion deformity of the spine. *J Bone Joint Surg Am* 1968; 50: 287-294.
- [4] Thiranont N, Netrawichien P. Transpedicular decancellation closed wedge vertebral osteotomy for treatment of fixed flexion deformity of spine in ankylosing spondylitis. *Spine (Phila Pa 1976)* 1993; 18: 2517-2522.
- [5] Bridwell KH, Lewis SJ, Edwards C, Lenke LG, Iffrig TM, Berra A, Baldus C, Blanke K. Complications and outcomes of pedicle subtraction osteotomies for fixed sagittal imbal-

- ance. Spine (Phila Pa 1976) 2003; 28: 2093-2101.
- [6] Kiaer T, Gehrchen M. Transpedicular closed wedge osteotomy in ankylosing spondylitis: results of surgical treatment and prospective outcome analysis. Eur Spine J 2010; 19: 57-64.
- [7] Santos ER, Ledonio CG, Castro CA, Truong WH, Sembrano JN. The accuracy of intraoperative O-arm images for the assessment of pedicle screw position. Spine (Phila Pa 1976) 2012; 37: E119-125.
- [8] Ammirati M, Salma A. Placement of thoracolumbar pedicle screws using O-arm-based navigation: technical note on controlling the operational accuracy of the navigation system. Neurosurg Rev 2013; 36: 157-162.
- [9] Larson AN, Santos ER, Polly DW Jr, Ledonio CG, Sembrano JN, Mielke CH, Guidera KJ. Pediatric pedicle screw placement using intraoperative computed tomography and 3-dimensional image-guided navigation. Spine (Phila Pa 1976) 2012; 37: E188-94.
- [10] Kotani T, Akazawa T, Sakuma T, Koyama K, Nemoto T, Nawata K, Yamazaki A, Minami S. Accuracy of Pedicle Screw Placement in Scoliosis Surgery: A Comparison between Conventional Computed Tomography-Based and O-Arm-Based Navigation Techniques. Asian Spine J 2014; 8: 331-338.