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Computer-assisted anterior reconstruction surgery for a thoracolumbar fracture: a case report

Torakolomber kırığın bilgisayar destekli anterior rekonstrüksiyonla tedavisi: Olgu sunumu

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Application of the computer-assisted navigation system to the anterior approach is considered difficult due to smooth topography of the anterior vertebrae. In this case report, we presented our modification of computer-assisted image-guided navigation to perform anterior thoracolumbar reconstruction in a 50-year-old female patient with an osteoporotic compression fracture without cord compression at the L_{1-2} level. In the right lateral decubitus position, the anterior and lateral aspects of the T_{12}, L_1, and L_2 vertebrae were approached via an extrapleural-retroperitoneal route. Two screws were percutaneously inserted into the spinous process of the L_1 vertebra, and the dynamic reference frame (DRF) was fixed to the screws after rubber wrapping. Vertebral body screws were inserted after the registration. After anterior release, the DRF and the screws in the spinous process were removed prior to a reduction maneuver. The operation time was 240 minutes. Postoperative imaging studies showed adequate decompression of the spinal canal and an anatomically correct spinal reconstruction. The preoperative kyphotic angle of 50 degrees decreased to 20 degrees after the surgery. There were no complications associated with the use of the computer-assisted navigation system.

Key words: Bone screws; lumbar vertebrae/surgery/radiography; spinal fusion/instrumentation; stereotaxic techniques; therapy, computer-assisted; tomography, X-ray computed.

Bilgisayar destekli navigasyon sisteminin anterior yaklaşımda kullanılması, anterior vertebranın düz topografisi nedeniyle zordur. Elli yaşındaki bir kadın hastanın, L_{1-2} düzeyinde kord kompresyonuna yol açmayan osteoporotik kompresyon kırığı, bilgisayar destekli görüntülemede modifikasyon yapılarak anterior torakolomber rekonstrüksiyon ile tedavi edildi. Hasta sağ lateral dekubitus pozisyonunda yatırılarak, T_{12}, L_1 ve L_2 vertebraların anterior ve lateral yüzlerine ekstraplevral-retroperitoneal yolla girildi. Önce, L_1 vertebranın spinöz çıkıntısına perkütan iki adet vida yollandı ve dinamik referans çerçevesi lastikle sarılan vidalara sabitlendi. Rejistrasyon yapıldıktan sonra vertebral cisim vidaları yollandı. Anterior dekompresyon tamamlandıktan sonra, dinamik referans çerçevesi ve spinöz çıkıntıya yollanan vidalar çıkarılarak redüksiyon manevrasına devam edildi. Ameliyat 240 dakika sürdü. Ameliyat sonrası radyolojik incelemelerde, spinal kanalda yeterli dekompresyon sağlandığı ve anatomik olarak uygun bir rekonstrüksiyon gerçekleştirildiği görüldü. Hastanın ameliyattan önce 50 derece olan kifoz açısı ameliyattan sonnra 20 dereceye düştü. Bilgisayar destekli navigasyon sistemiyle ilgili herhangi bir komplikasyon gelişmedi.

Anahtar sözcükler: Kemik çivisi; lomber vertebra/cerrahi/radyografi; spinal füzyon/enstrümantasyon; stereotaksik teknikler; tedavi, bilgisayar yardımlı; bilgisayarlı tmografi.

Computer-assisted navigation system was first developed for transpedicular screw fixation in 1995.[1] The system has gradually evolved to improve a spine surgeon's orientation to the nonvisualized anatomy during complex spinal procedures.[2-6] It provides the accuracy of a direct open surgical approach while optimizing patient safety. Therefore, it is a helpful tool for both the beginner and experienced surgeons in preoperative planning, intraoperative surgical guidance and instrument tracking.

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However, because the instruments of the system were initially developed for posterior approaches, direct application to anterior approaches is limited. The use of computer-assisted navigation system is more demanding in unfamiliar anterior pathological surgical field because there are potentially serious vascular injury-related complications. The authors have used a commercially available stereotactic navigation system in various spinal surgeries since 1997.

The management of osteoporotic compression fractures of the thoracolumbar spine is under the influence of several factors, such as accompanying spinal cord compression, the possibility of posterior augmentation, osteoporotic condition, and the patient's age. In this case report, the authors describe a modified surgical technique of image-guided anterior thoracolumbar reconstruction for the treatment of osteoporotic compression fractures in the thoracolumbar spine.

CASE REPORT

A 50-year-old female patient had progressive back pain of 2-year history, paraparesis, and urinary incontinence. The osteoporotic compression fracture was caused by a fall that occurred 10 years ago. Preoperative radiological studies demonstrated a thoracolumbar kyphotic deformity of 50 degrees due to an L_{1-2} compression fracture without cord compression (Fig. 1). The patient underwent anterior thoracolumbar reconstruction with the use of image-guided navigation. After surgery, kyphotic angle was measured as 20 degrees on a lateral radiograph (Fig. 2). The operation time was 240 minutes. There were no intraoperative complications. Postoperative imaging studies revealed an adequate decompression of the spinal canal as well as an anatomically correct spinal reconstruction.

Surgical technique

We used the Surgical Tool Navigation (STN; Zeiss, Germany), which utilizes an infrared beam to detect intraoperative position of the patient and instruments. Preoperative data from axial computed tomography images (slice thickness, 1 mm) are used for the basic data for navigation. This system consists of a computer workstation, a dynamic reference frame (DRF), a standard probe, a localizer for drill and an electro-optical camera connected to the computer workstation. The infrared beams from the DRF, the standard probe, and the localizer for drill are detected by the electro-optical camera and visualized on a three-dimensional reconstruction image in real-time.

The patient was positioned in the right lateral decubitus position, and the anterior and lateral aspects of the T_{12}, L_1, and L_2 vertebrae were approached via an extrapleural-retroperitoneal route. Two screws were percutaneously inserted into the spinous process of the L_1 vertebra, and the DRF was fixed to the screws after rubber wrapping

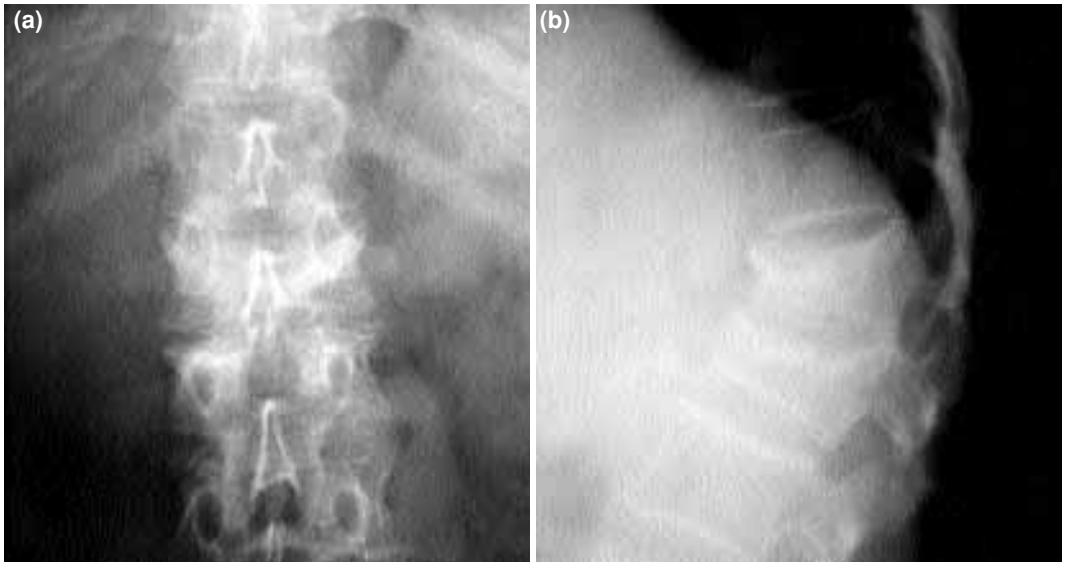

Fig. 1. Preoperative X-rays. **(a)** Anteroposterior and **(b)** lateral views demonstrating a kyphotic angle of 50 degrees.

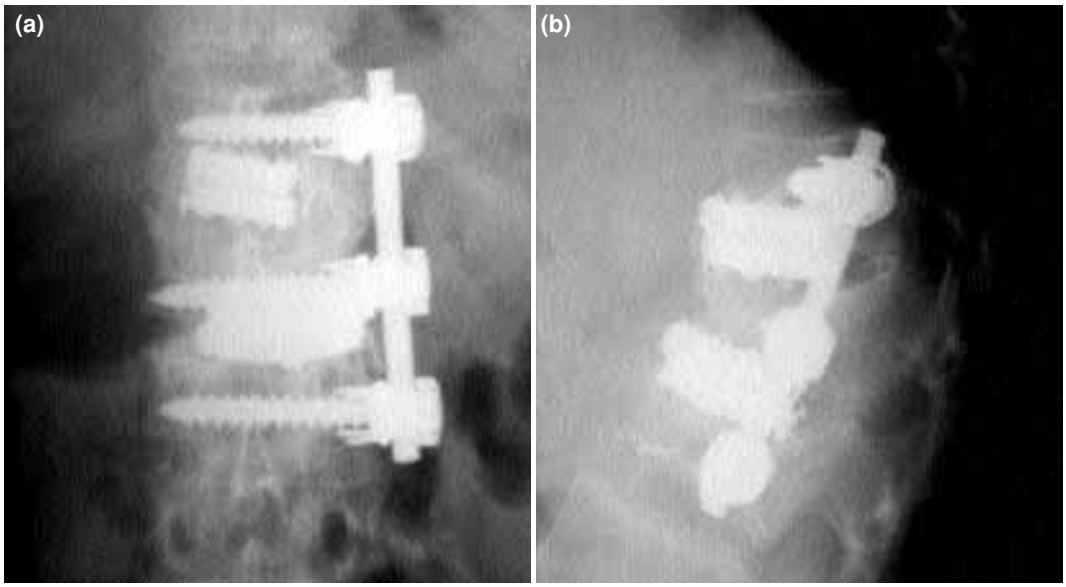

Fig. 2. Postoperative X-rays. **(a)** Anteroposterior and **(b)** lateral views demonstrating accurate screw placement. A kyphotic angle of 20 degrees is seen on the lateral view.

(Fig. 3). The paired-point registration of fibrotic fused segments from T_{12} to L_2 was successfully carried out with the 12th rib head, the most left lateral point of $L_{1\text{-}2}$ vertebrae and the root of L_1 left pedicle (Fig. 4). The time for registration was 2 minutes, and the registration error was 1.34 mm. After the registration, vertebral body screws were inserted, and then, the computer-assisted navigation system was used to confirm the location of bony spurs overlying the disc space and the direction of the disc space. During discectomy, the depth and posterior extension were intermittently checked using the standard probe. After anterior release, the DRF and screws in the spinous process were removed prior to a reduction maneuver. Distraction, pushing back, insertion of cages, and rod fixation were performed without the help of computer-assisted navigation system.

DISCUSSION

There are numerous effective treatment options for correcting a kyphotic deformity.[7] We demonstrated that thoracolumbar corpectomy and spinal reconstruction for the treatment of osteoporotic compression fractures could be performed using image-guided navigation.

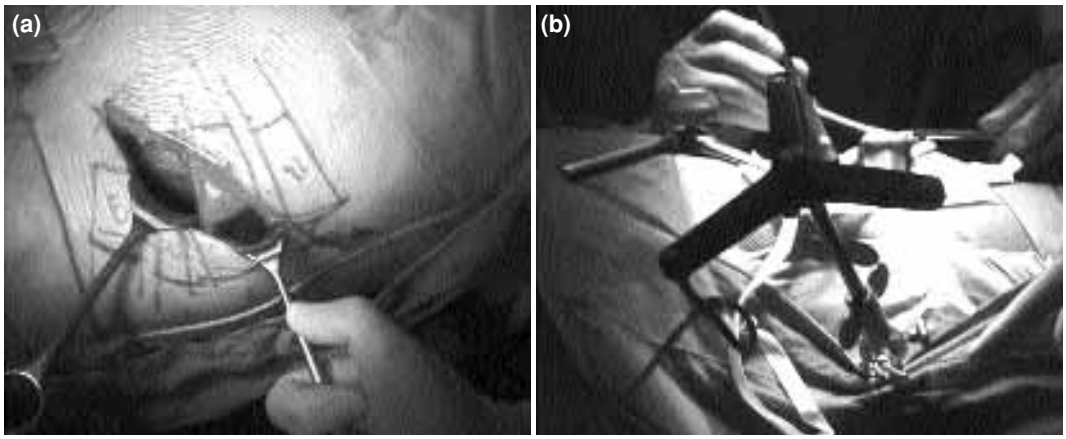

Fig. 3. Intraoperative views. **(a)** The patient is in the right lateral decubitus position, and an extrapleural-retroperitoneal approach is used for the anterior and lateral aspects of T_{12}, L_1, and L_2 vertebrae. **(b)** Two screws are percutaneously inserted into the L_1 spinous process, and the dynamic reference frame is percutaneously fixed to the L_1 spinous process.

In our case, the cause of kyphosis was multiple compression fractures without direct neurological compression. Considering the possibility of reoperation (like posterior augmentation), the osteoporotic condition (T-score, 77%), and the patient's young age (50 years old), we selected the anterior approach. To minimize both the number of upper lumbar segments fused and the impact force on the osteoporotic vertebral body, an anterior release and fusion between compressed vertebral bodies were attempted instead of corpectomy and fusion. A precise anterior release to maximally preserve compressed bodies is indispensable in this case. C-arm fluoroscopy is used for this purpose, but even a high-resolution device is not always able to provide clear-cut data in intermingled pathologic conditions, such as collapsed disc height with overlying bony spurs. Although it is of virtual reality, the computer-assisted navigation system provides three-dimensional data with minimal error at a fixed target as seen in this case. More importantly, it familiarizes the surgeon with abnormal anatomical structures during the preoperative planning and difficult registration step in the real surgical field.

Albert et al.[8] and Klein et al.[9] reported the use of computer-assisted navigation system in the anterior approach in cadaveric studies. Although the STN was initially developed for brain or posterior spinal surgery, we applied computer-assisted navigation system in the anterior approach with some modifications. In posterior spinal surgery, the instruments are usually detected without difficulty due to the shallow operative field, and the DRF is easily fixed to the spinous process. In this case, however, due to the deep operative field, the usual cranial or caudal locations of the camera were unable to detect the instruments, which move in almost perpendicular directions. This problem was overcome by laterally locating and lowering the height of the camera. Fixing the DRF to the rib in the surgical wound was contraindicated because of a high likelihood of errors due to respiratory movement or retractor manipulation. Therefore, two screws of cervical Caspar retractors were inserted percutaneously into the spinous process of the L_1 vertebra, wrapped with a rubber band, whereby a tight attachment of the DRF was then possible. We were able to eliminate errors resulting from respiratory movement and infrared beam obstruction in the deep operative field, by changing the camera location and using a new DRF fixation technique.

Registration is another major limitation in using the computer-assisted navigation system for anterior thoracolumbar surgery. Klein et al.[9] demonstrated that the smooth topology of the anterior cervical spine and the relatively small

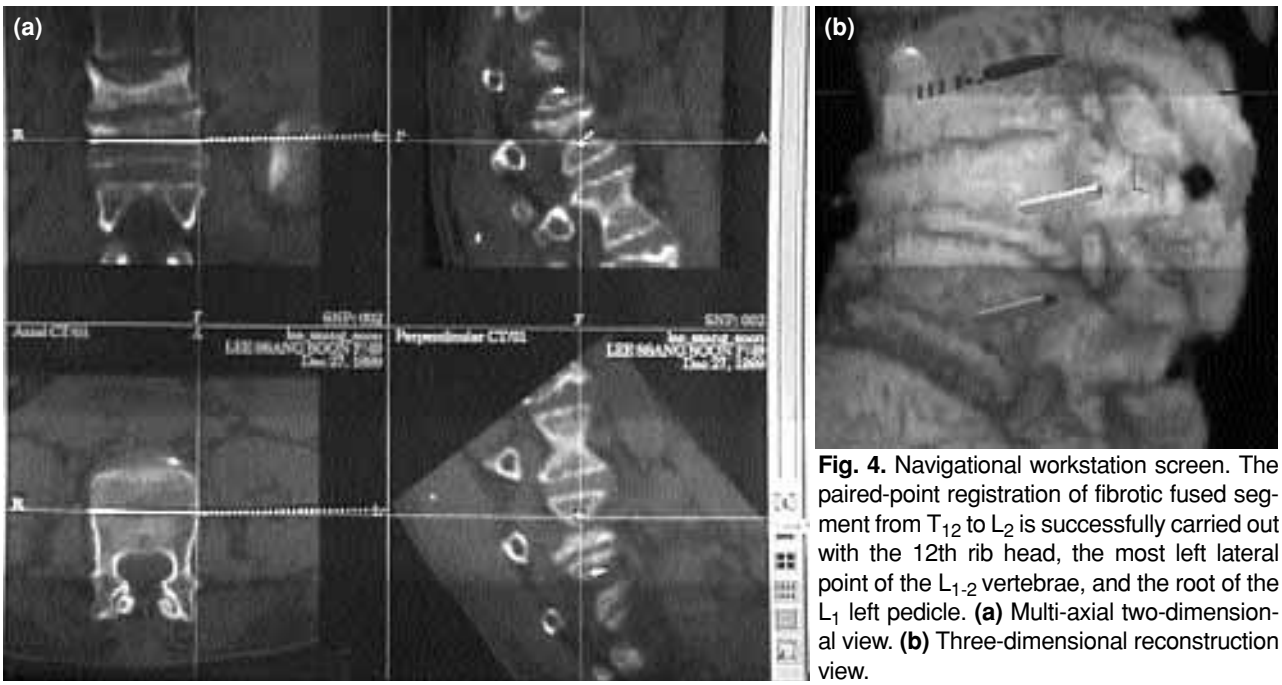

Fig. 4. Navigational workstation screen. The paired-point registration of fibrotic fused segment from T_{12} to L_2 is successfully carried out with the 12th rib head, the most left lateral point of the $L_{1\text{-}2}$ vertebrae, and the root of the L_1 left pedicle. **(a)** Multi-axial two-dimensional view. **(b)** Three-dimensional reconstruction view.

exposure might make registration difficult. In posterior spinal surgery, repeatedly discernible bony structures such as the transverse process and the spinous process are used for registration and intraoperative rechecking. The exact exposure of these structures is the key to the successful use of computer-assisted navigation system in the face of soft tissue adhesions. However, in certain pathological conditions, as in the case presented, easily discernible bony structures are present. In addition, these structures are easily exposed as seen when using a posterior approach. The expected difficulty in the registration did not occur. Since the STN is not a specific computer-assisted navigation system for anterior spinal surgery, we were not able to perform the whole operative procedure using this system. However, we obtained the critical anatomical information from the operative field and performed the important steps with the help of three-dimensional monitoring in real-time. The use of computer-assisted navigation system offers increased safety in surgically challenging cases. Therefore, the computer-assisted navigation system is appropriate for anterior spinal surgery, and the development of accessory tools will promote its applicability and effectiveness.

Our technical modification of the computer-assisted navigation system was found helpful in thoracolumbar corpectomy and spinal reconstruction for the treatment of osteoporotic compression fractures. However, its effectiveness merits justification in large clinical trials. In our case we had no specific difficulties or method-related complications. For practical use of image-guided navigation in anterior spinal surgery, development of appropriate accessories seems to be indispensable.

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