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Percutaneous thoracic disc decompression with laser-assisted spinal endoscopy under CT fluoroscopy guidance

Bilgisayarlı tomografi-floroskopi eşliğinde lazer yardımlı spinal endoskopla perkütan torasik disk dekompresyonu

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Objectives: Thoracic discs are difficult to approach surgically. Computed tomography (CT) fluoroscopy provides accurate spatial information and real-time information. The purpose of this study is to present percutaneous thoracic disc decompression (PTDD) with laser-assisted spinal endoscopy (LASE) under CT fluoroscopy guidance as a new minimally invasive procedure for symptomatic thoracic disc herniation.

Patients and methods: Eight consecutive patients (6 males, 2 females; mean age 34.5 years; range 23 to 49 years) with intractable thoracic axial and/or radicular pain due to soft disc herniation underwent PTDD with LASE under CT fluoroscopy guidance. With the help of a live image, the ipsilateral or central portion of the protruded disc was decompressed via the posterolateral approach. All the patients were discharged in less than 24 hours. Evaluations were made with the use of the Oswestry Disability Index (ODI), a visual analog scale (VAS), and according to the modified Macnab criteria. The mean follow-up period was 16.8 months (range 13 to 21 months).

Results: The mean operating time was 65 minutes (range 45 to 90 minutes). The mean VAS score was 6.5 (range 5-8) before the procedure and 1.9 (range 0-4) at the final follow-up. The mean ODI score decreased from 55 (range 48-86) preoperatively to 16.5 (range 0-30) at the final follow-up. According to the Macnab criteria, the results were excellent in six patients (75%), good in one patient (12.5%), and fair in one patient. No postoperative complications occurred and none of the patients required open surgery.

Conclusion: In selected patients, PTDD with LASE under CT fluoroscopy guidance is an accurate, safe, and effective minimal invasive procedure for symptomatic thoracic disc herniation.

Key words: Diskectomy, percutaneous/methods; fluoroscopy/methods; intervertebral disk displacement/surgery/radiography; thoracic vertebrae/surgery; tomography, X-ray computed.

Amaç: Torasik disklere cerrahi yaklaşım zordur. Bilgisayarlı tomografi (BT)-floroskopi doğru spatial ve gerçek-zamanlı bilgi sağlamaktadır. Bu çalışmada, semptomatik torasik disk herniasyonunda yeni bir minimal invaziv prosedür olarak BT-floroskopi rehberliğinde lazer yardımlı spinal endoskopi (LASE) ile perkütan torask disk dekompresyonu (PTDD) yöntemi sunuldu.

Hastalar ve yöntemler: Yumuşak disk herniasyonuna bağlı ve tedaviyle iyileşmeyen torasik aksiyel ve/veya radiküler ağrı nedeniyle ardışık sekiz hastaya (6 erkek, 2 kadın; ort. yaş 34.5; dağılım 23-49) BT-floroskopi rehberliğinde ve LASE ile PTDD uygulandı. Canlı görüntü altında ve posterolateral yaklaşımla, protrüzyonlu diskin ipsilateral ya da santral bölümüne dekompresyon uygulandı. Tüm hastalar 24 saat içinde taburcu edildi. Değerlendirmelerde Oswestry Disabilite İndeksi (ODI), görsel analog skala (GAS) ve modifiye Macnab ölçütleri kullanıldı. Ortalama izlem süresi 16.8 ay (dağılım 13-21 ay) idi.

Bulgular: Ortalama ameliyat süresi 65 dakika (dağılım 45-90 dakika) bulundu. Ortalama GAS skoru ameliyat öncesinde 6.5 (dağılım 5-8), son kontrolde 1.9 (dağılım 0-4) bulundu. Ameliyat öncesinde ortalama 55 (dağılım 48-86) olan ODI skoru son kontrolde 16.5'e (dağılım 0-30) düştü. Macnab ölçütlerine göre, altı hastada (%75) mükemmel, bir hastada (%12.5) iyi, bir hastada da orta sonuç alındı. Ameliyat sonrasında komplikasyon görülmedi ve hiçbir hastada açık cerrahi gerekmedi.

Sonuç: Seçilmiş hastalarda semptomatik torasik disk herniasyonunda, BT-floroskopi rehberliğinde LASE ile PTDD kesin, güvenli ve etkili bir minimal invaziv tedavi yöntemidir.

Anahtar sözcükler: Diskektomi, perkütan/yöntem; floroskopi/yöntem; intervertebral disk deplasmanı/cerrahi/radyografi; torasik vertebra/cerrahi; bilgisayarlı tomografi.

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Thoracic disc herniation has been considered a relatively rare disease. Arce and Dohrmann[1] reported the incidence of protruded disks occurring in the thoracic region as 0.25 to 0.75%. The most common symptoms are pain, numbness and weakness in the lower limb, paresthesia, and sphincteral dysfunction.[2] Patients who complain of thoracic axial pain and/or thoracic radicular pain without a severe neurologic deficit or prominent radiologic abnormality are often treated conservatively. When symptoms are not responsive to conservative treatments including physical therapy or adequate analgesics, the need for surgical treatment emerges.

The choice of operative approach will depend upon a number of factors including the characteristics of the disc (localization, size, and calcification), spinal cord compression, patient's condition, and the surgeon's technical experience.[3,4] Classically, because of broad visualization, open approaches are commonly used for thoracic disc herniation, including transpedicular discectomy, thoracotomy, and costotransversectomy.[5-8] However, these open surgeries require general anesthesia, the dissection of muscle, and the removal of bone, and postoperatively, a prolonged recuperation and hospitalization.

In recent years, various types of fluoroscopy-guided minimally invasive endoscopic techniques under local anesthesia have been developed to avoid open surgery-related complications in the cervical and lumbar region.[9-14] However, the thoracic spine has unique anatomical and biomechanical properties. Access to the thoracic disc under fluoroscopy guidance may not be easy even for the experienced surgeon because of limited visualization. By contrast, computed tomography (CT) fluoroscopy, which is one of the most recent advances in interventional radiology, provides accurate spatial and real-time information.[15-18]

Ho:YAG (Holmium:Yttrium-Aluminium-Garnet) laser is a useful tool for minimally invasive disc decompression.[9-14,19] Laser-assisted spinal endoscopy (LASE; Clarus, USA), which integrates Ho:YAG laser, endoscopy, illumination, and irrigation, allows vaporization and shrinkage of disc tissue through a small cannula. The authors have been using LASE since 1992, and it proved to be safe for disc decompression in percutaneous endoscopic spinal surgery.

In this study, the authors present their experience with percutaneous thoracic discectomy (PTDD) with LASE under CT fluoroscopy guidance as a new minimally invasive procedure for symptomatic thoracic disc herniation.

PATIENTS AND METHODS

Patient selection

Between March to November 2003, eight consecutive patients were treated with real-time CT-guided PTDD with LASE under institutional review board study protocol. There were six males and two females with a mean age of 34.5 years (range 23 to 49 years). The inclusion criteria for the study were as follows: *(i)* the presence of interscapular central thoracic pain and/or radiating anterior chest pain; *(ii)* contained soft disc herniation in the thoracic spine, confirmed by CT and magnetic resonance imaging (MRI); *(iii)* a positive response to a diagnostic selective nerve root block, that correlated with symptoms and radiological images; and (iv) lack of response after a minimum of six months of conservative treatments. Patients with a definite calcified disc, ossification of the posterior longitudinal ligament, posterior osteophytic bar, myelopathy, or significant motor weakness were excluded. When any doubt existed as to the diagnosis and the cause of the symptoms, the patient was examined by an internist to rule out other causes of thoracic pain.

The clinical outcome was assessed with the use of the Oswestry Disability Index (ODI), a visual analog scale (VAS), and according to the Macnab criteria.[20-22] The patients were followed for a mean of 16.8 months (range 13 to 21 months). Statistical analyses were made using the Wilcoxon's signed-rank test.

Surgical technique

The procedure is performed via a posterolateral approach. The patient is placed prone on the sliding table of CT (Somatom Sensation 4; Siemens, Erlangen, Germany) and conscious sedation is used so that the patient is able to respond (Fig. 1). The back is prepped and draped in the usual sterile fashion. Under CT guidance, a spinal needle is used to identify the affected disc level. An imaginary line is drawn on the CT image to delineate the

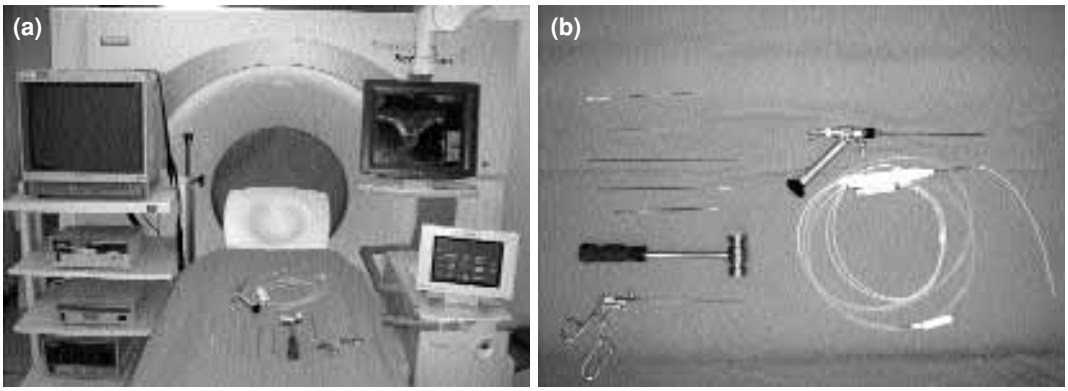

Fig. 1. Operation room set up. **(a)** Interventional CT (Somatome Sensation 4, Siemens) and Ho:YAG laser-assisted endoscopic system. **(b)** Surgical instruments and laser-assisted spinal endoscopy (LASE) kit.

proper operating trajectory, and the skin is marked accordingly (Fig. 2a).

The skin entry point is approximately 3 to 7.5 cm off the midline. Under local anesthesia and CT fluoroscopy guidance, a 20 gauge spinal needle is incrementally introduced from the previously marked entry point along the imaginary line (Fig. 2b), aiming toward the center of the disc along the costovertebral groove (Fig. 3). After the annulus is punctured, the needlepoint is advanced to the posterior one-third of the disc. Discography is performed with contrast media including indigo carmine to identify the pathologic lesion. A thin guidewire is inserted through the needle channel into the center of the disc. The needle is then removed, and a small skin incision is made at the entry site of the needle. The first dilating cannula is passed over the guidewire. The guidewire is exchanged with a thin cannula for rigid guidance and then a serial dilating cannula is inserted. A 3-mm final working sheath is positioned within the posterior one-third of the disc space under CT guidance (Fig. 4, 5). Using the real-time cross-section images, the ipsilateral or central portion of the protruded disc is decompressed with an automated nucleotome and microforceps. During the procedure, the patient is asked what the pain felt like or if the pain has disappeared. The procedure is finished after checking the patient's symptom relief. Finally, the disc tissue is potentially more shrunk and annuloplasty is performed using the Ho:YAG laser under endoscopic view. The working sheath is removed after checking the bleeding point with endoscopy.

RESULTS

A total of nine discs were excised in eight patients, which included T_{2-3} (n=3), T_{5-6} (n=1), T_{6-7} (n=2), T_{7-8}

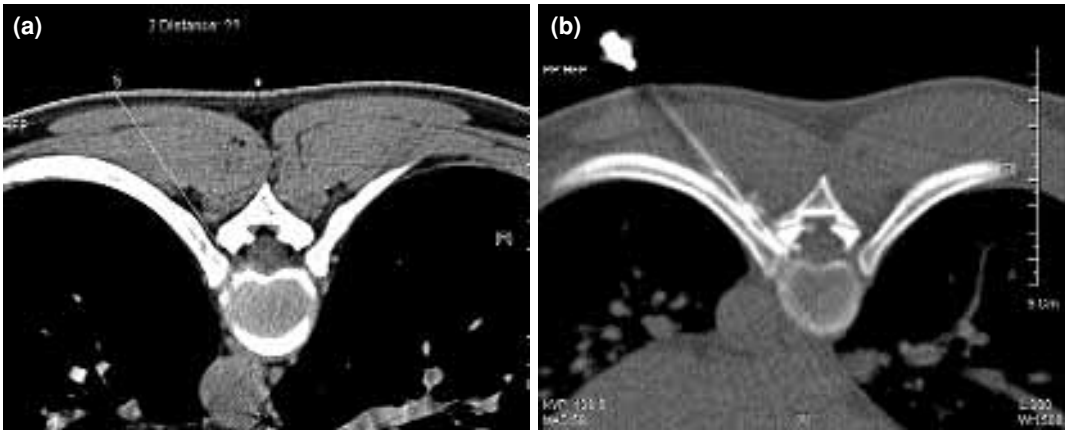

Fig. 2. Determination of the approach route with interventional CT. **(a)** An imaginary line of trajectory is drawn to determine the entry point. **(b)** Insertion of the spinal needle into the disc space along the imaginary line under CT guidance.

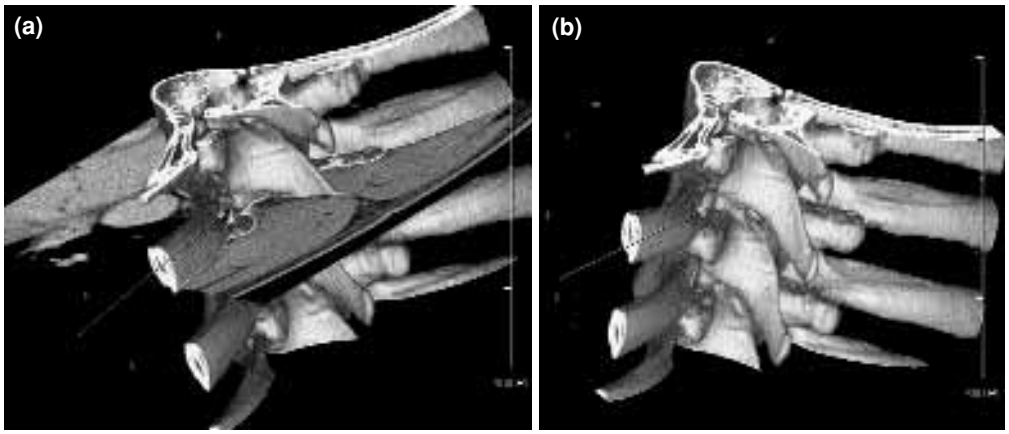

Fig. 3. (a, b) The appearance of the anatomical space for the cannula passage on 3D images. (arrow: the groove between the rib and facet).

(n=2), and T_{8-9} (n=1). The mean total laser energy applied was 3,808 J (range 1150 to 6500 J). The mean operating time per level was 65.0 minutes (range 45 to 90 minutes). No blood transfusion was necessary.

All the patients were discharged form hospital within less than 24 hours. The mean VAS scores before the procedure, three months after the procedure, and at the final follow-up were 6.5 (range 5-8), 1.6 (range 0-6), and 1.9 (range 0-4), respectively. The mean ODI score which was 55.0 (range 48-86) preoperatively decreased to 15.0 (range 10-38) at the end of postoperative three months, but showed a slight increase to 16.5 (range 0-30) at the final follow-up.

There was a significant improvement in the VAS (p=0.0112) and ODI scores (p=0.0113) at the end of postoperative three months, and this improvement maintained throughout the follow-up period. According to the Macnab criteria, surgi-

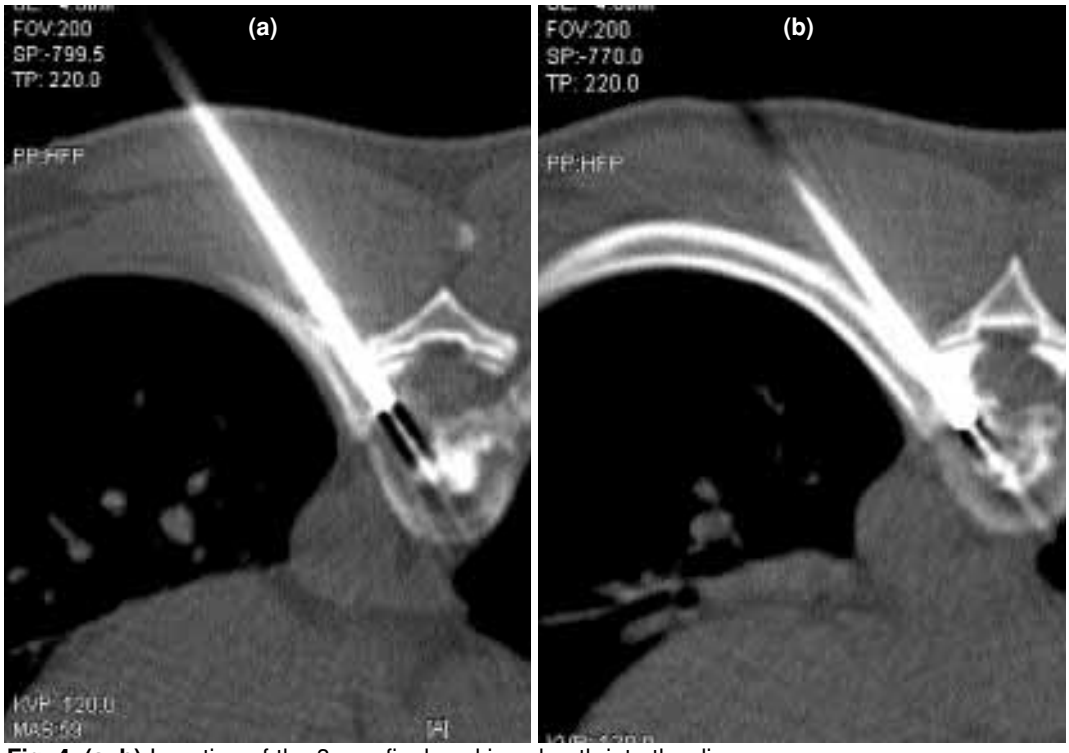

Fig. 4. (a, b) Insertion of the 3-mm final working sheath into the disc space.

cal outcome was excellent in six patients (75.0%), good in one patient (12.5%), and fair in one patient, indicating an overall symptomatic improvement in 87.5%. There were no postoperative complications and none of the patients required conversion to open surgery.

DISCUSSION

Fluoroscopy has been widely and successfully used as a guide during most percutaneous discectomy procedures in the cervical and lumbar region.[9-14] However, thoracic disc diseases present less convenience for fluoroscopic guidance. Thoracic discs are difficult to approach surgically because of the ribs, the segmental vessels, and the narrow spinal canal. The head of the rib covers the disc posterolaterally and overlies a portion of the neural foramen. The segmental vessels course along the midbody of the vertebrae. The thoracic spinal cord is relatively small, yet the ratio of the spinal cord to the spinal canal is greater than that in the cervical or lumbar regions. Therefore, access to the thoracic disc under fluoroscopy guidance is not easy even for experienced surgeons.

Conventional CT provides better visualization of the lesion and surrounding structures, but its main drawback is the lack of real-time guidance. Real-time CT has recently been advocated for interventional procedures.[15-18] The integrated fluoroscopic CT system uses a slip-ring helical CT scanner with a high-speed array processor that allows image reconstruction and display of images at three to six frames per second, resulting in near-real-time reconstruction and visualization.

In this study, we performed real-time CT-guided PTDD with LASE in eight patients with symptomatic thoracic disc herniation. To our knowledge, the use of CT fluoroscopy for PTDD has not been described in the literature. With the help of a live image, we could advance the needle and the cannula and watch the procedure. Real-time imaging allowed us to remove the protruded disc, it reduced the exam time, as well.

It was difficult to compare our results with those reported in other studies due to differences in the patients' condition, surgical experience and methods, and in the criteria to evaluate surgical outcomes.

In 2002, Anand and Regan[23] reported the results of video-assisted thoracoscopic surgery in 100 patients. The average operative time was 173 minutes, the mean blood loss was 261 ml, and the mean duration of hospitalization was four days. They reported an overall patient satisfaction rate of 84% and a clinical success rate of 70% at the end of a four-year follow-up period. In 2004, Perez-Cruet et al.[24] reported their experience with thoracic microendoscopic discectomy in seven patients. The mean operation time per level, blood loss, and

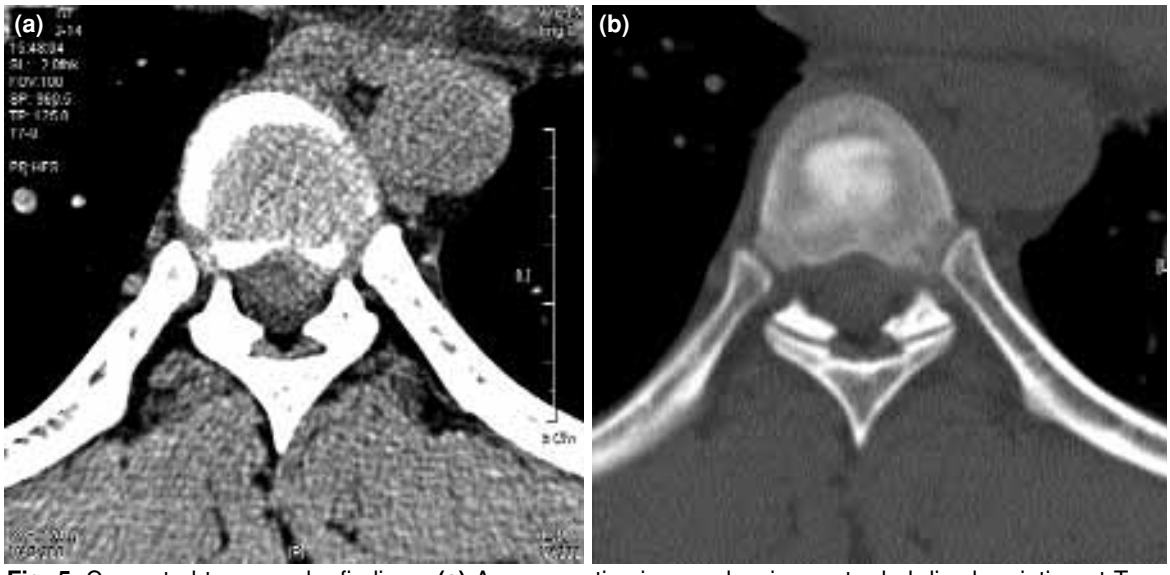

Fig. 5. Computed tomography findings. **(a)** A preoperative image showing protruded disc herniation at T_{7-8}. **(b)** Postoperative image after removal of disc herniation.

hospital stay were 102 minutes, 111 ml, and 1.6 days. At the end of a nine-month follow-up period, the results were excellent in five patients (71.4%), good in one (14.3%), and fair in one patient according to a modified Prolo Scale.

Clinical outcomes in our study were similar to those reported in these studies. However, the mean operative time and hospital stay in our study were much shorter than those of microendoscopic discectomy or video-assisted thoracoscopic discectomy. Contrary to those surgeries performed under general anesthesia, we used local anesthesia, and all the patients felt pain relief immediately following the procedure. Compared with preoperative values, VAS and ODI scores significantly decreased at the end of three months, and this improvement maintained throughout the follow-up period.

In our study, no postoperative complications developed and no patient required conversion to open surgery. Real-time CT guidance via the posterolateral approach almost eliminates various complications, such as pneumothorax, lung injuries, and major vascular injuries or injuries to the spinal cord, which are otherwise likely to occur due to improper adjustment of the probe. Our results show that CT fluoroscopy is a safe and effective guidance modality for PTDD. Real-time visualization of the lesion and surrounding structures under CT guidance help reduce the operation time and complications, and increase both the patient's safety and surgeon's confidence.

In our study, the efficacy and reliability of thoracic discograms were not fully conclusive. Schellhas et al.[25] reported that concordant pain associated with thoracic discography occurred in 50% of patients who had compatible clinical symptoms with disc protrusion on MRI findings. We performed thoracic discography in all the cases, and concordant pain or similar bizarre pain were elicited, but the value of thoracic discogram could not be estimated.

Appropriate patient selection is very important when considering PTDD with LASE under CT fluoroscopy guidance because it influences the success rate of this surgery. In comparison with asymptomatic thoracic disc herniation which has a prevalence of approximately 7-15%, symptomatic thoracic disc herniation is rare, accounting for 0.25 to 0.75% of all disc herniations reported in the literature.[1,26] With improved diagnostic methods of MRI and postmyelographic CT scanning, recent studies reported the prevalence of thoracic disc herniations as 11.1% to 14.5%.[27,28] It should be borne in mind that the symptoms of many other disorders such as lumbar disc herniation, and cardiac, abdominal, and intrathoracic diseases may mimic thoracic disc herniation.[2] Therefore, attempts for an accurate and differential diagnosis are important. In our study, when any doubt existed as to the cause of symptoms, an internist evaluated the patient to rule out other causes of thoracic pain. In particular, special attention was given to rule out myofacial syndrome.

The Ho:YAG laser is also a useful tool for minimally invasive disc decompression.[9-14,19] Irradiation can be performed with saline irrigation, with the tissue penetration of Ho:YAG being approximately 0.4 mm deep. Therefore, the volume of the tissue heated by the laser is very small, and heat-induced damage to the surrounding normal tissue is negligible. In this study we used LASE, which integrates straight-firing Ho:YAG laser, endoscopy, illumination, and irrigation. Since LASE consists of a flexible and remote-control fine cable, it is easy to manage the direction of the laser beam. These advantages of LASE allowed safe vaporization and shrinkage of the disc tissue through a small cannula. Since 1992, the authors have been using LASE for percutaneous spinal disc decompression in patients with symptomatic soft disc herniations.

The number of patients with objective neurologic findings associated with soft thoracic disc herniation is very low, and most patients can be treated conservatively. In general, most surgeons hesitate to attempt surgical treatment in a patient with symptomatic thoracic disc herniation because of potential risks for spinal cord injuries. Therefore, minimally invasive procedures for contained soft disc herniations are still controversial especially for those in the thoracic region. Thoracoscopic discectomy will be the first choice for patients with myelopathy or significant motor weakness.[23,29] However, since early symptoms of thoracic disc herniation are not fully characterized, the decision for interventional treatment is usually delayed, which brings about an increased risk for

complications. To our experience, PTDD with LASE under CT fluoroscopy guidance is effective for selected patients with minor symptoms that remain unresponsive after six months of conservative treatment, but still are not severe enough for traditional open surgery. It may also serve as an effective preventive surgery in patients with upper motor neuron sings before the development of paraparesis or leg weakness.

Percutaneous thoracic discectomy with LASE under CT fluoroscopy guidance is a safe and effective minimally invasive procedure for symptomatic thoracic disc herniation in selected patients who are not candidates for conventional open surgery. Real-time CT guidance reduces the operation time and complications, and increases safety and confidence on the part of the patients and surgeons, respectively. Yet, further studies are needed to evaluate this procedure with its long-term results.

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