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Review

Image-guided percutaneous mechanical disc decompression for herniated discs: a technical note

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Summary. Interventional radiology plays a key role in the treatment of symptomatic herniations of intervertebral discs. Through image-guided techniques, it is possible to use minimally invasive procedures with a percutaneous approach that are usually proposed before classic surgery. Thanks to imaging guidance, it is possible to significantly increase accuracy and decrease complication rates. The pivotal principle of these mini-invasive techniques is to remove a small amount of volume of the nucleus of the intervertebral disc which results in a significant reduction in intradiscal pressure; allowing for a consequent reduction in compression of the nervous structures that generate spinal pain. However, it must be considered that this type of treatment is only addressed to contained disc herniations previously diagnosed with a suitable neuroimaging examination. There are different types of treatment using a variety of chemical, thermal or mechanical processes that result in partial removal of the nucleus pulposus. The purpose of this technical note is to illustrate mechanical disc decompression treatment via a percutaneous approach using the DISKOM device (DISKOM percutaneous discectomy probe, Biopsybell, Mirandola, Italy). Indications, complications and various methods of use are described in relation to the different levels of the spine to be treated. (www.actabiomedica.it).

Keywords: Disc herniation; percutaneous discectomy; fluoroscopy; spine; interventional radiology; pain management

Introduction

Spinal pain is one of the most frequently reported diseases in the industrialized world and is related to disability, work absence, and extensive costs in the health system (1). Minimally invasive intradiscal procedures are considered an alternative treatment and are usually proposed before classic surgical approaches.

The need to reduce complications, to improve long-term outcomes, and to minimize sub-optimal results that occasionally accompany disc surgery in herniated discs, have encouraged the development of other techniques in order to prevent open surgery through the spinal canal.

Using these methods, the reported complication rate is lower because the native disc structure is preserved and the surrounding tissues are less damaged (2,3). The main goal of image-guided procedures is to avoid the major disadvantages of surgical treatment such as tissue trauma, and higher incidence of complications, and repeated surgeries (4).

An intervertebral disc, because of its highly specialized role and relatively susceptible nature, is one of the major sources of low back pain syndrome (5-7).

Aging, stress and traumas cause a disc degeneration phenomenon and a loss of volume of the nucleus pulposus, due to a decrease in proteoglycans and water concentration (8,9).

Hydrostatic pressure between the disc and vertebral endplates, plays a very important role in the regulation of nutrient supply to the disc and in removal of waste from cells of the nucleus pulposus which is an avascular structure. With aging, disease or injury, the disc degeneration progresses causing a drop in the hydrostatic pressure mechanism of regulation (10,11).

Treatment of discogenic pain is based on the theory that a small reduction in disc volume involving removal of part of the nucleus via surgical or minimally invasive methods, can result in a large change in intradiscal pressure.

By using image-guided techniques, it is possible to significantly increase accuracy and decrease complication rates (12).

The reason that these techniques work is postulated to be a reduction in intradiscal pressure in the nucleus, resulting in a prolapsed disc retraction, thus allowing nerve decompression and potentially, resolution of radicular pain. These mechanisms are based on the study of Hijikata in 1975 concerning the role of intradiscal pressure, which stated, "Reduction of intradiscal pressure reduced the irritation of the nerve root and the pain receptors in the annulus and peridiscal area" (13). According to several studies, the success rate of these techniques varies between 75 and 80% (4, 14,15).

Image-guided therapeutic procedures for intervertebral disc herniation are different interventional radiology techniques performed on intervertebral discs with a percutaneous approach, aimed at obtaining a partial ablation of the disc itself which uses a trocar to puncture the outer annulus of the disc. Through the trocar, a variety of thermal, chemical or mechanical ablative devices can be placed inside the nucleus pulposus resulting in its partial removal. The removal of internal nuclear material decompresses the disc with the least damage of surrounding tissues.

Our aim is to describe in particular a percutaneous discectomy technique using the mechanical decompression device DISKOM (DISKOM percutaneous discectomy probe, Biopsybell, Mirandola, Italy), to provide guidance regarding the patient selection process, technical consideration and possible complications associated with the procedure.

Before the Procedure

Before the procedure, it is necessary to know the entire medical history of the patient and carefully investigate clinical and instrumental data. The verification of normal blood coagulation is generally recommended 1 or 2 days before procedure in order to avoid, though rare, uncontrolled bleeding problems.

Benefits and potential risks must always be discussed between the interventional radiologist and the patient or referral doctor. The procedure is carefully outlined by the radiologist to the patient with an informative letter containing all the information and indications to follow after the procedure and informed consent is obtained.

Preoperative imaging generally begins with simple spinal column films that are almost always simple to perform and are inexpensive. These allow us to obtain initial information regarding bone elements, possible misalignment of the vertebrae and allow us to exclude further potential causes of pain such as joint facet arthrosis, spinal canal stenosis and fractures. Subsequently, neuroimaging studies suggestive of disc herniation to which the clinical symptoms correspond, are required. The reference diagnostic imaging method is a MRI with T1- and T2-weighting sequences. The MRI should be systematically performed before each intervertebral disc decompression procedure and only in case of MRI contraindication, a CT scan should be used (3,16,17).

Ideal candidates for the treatment include patients with symptoms resulting from single level disc herniation associated with evidence of nerve root compression. In these patients the first treatment to suggest is a medical therapy to be continued for about 4 to 6 weeks, such as analgesics, corticosteroids, muscle relaxants, bed rest and physiotherapy. The ineffectiveness of medical treatment, such as prolonged use of corticosteroids, may suggest a minimally invasive approach to the disc (16,17).

The main indications for percutaneous mechanical disc decompression include: spinal pain of discogenic origin due to contained intervertebral disc herniation, previously confirmed with dedicated imaging (preferably with a MRI); nonsignificant improvement after conservative medical therapy or neurological involvement attributable to a single nerve root compression with characteristic dermatomal pain distribution (12,16-20).

On the other hand, it is also important to emphasize the possible contraindications to the procedure. The main contraindications are concomitant spine diseases such as infections, tumors, sequestered disc fragment, stenosis of spinal canal or neural foramen, segmental instability as spondylolisthesis and pregnancy (because of fetal radiation exposure) (21-23). However, some physicians do not consider spondylolisthesis an absolute contraindication as long as there is an appropriate neurosurgical counseling (20). Other relative contraindications are represented by hemorrhagic diathesis or anticoagulant therapy (these conditions can be corrected before the procedure), severe degenerative disc disease with conspicuous reduction of disc height decrease, previous treatments at the same level and primary or metastatic malignancy (14,17,22-24).

Technique

Percutaneous disc decompression technique should be performed by an experienced and adequately trained interventional radiologist. The procedure is generally performed under fluoroscopy or CT guidance using a probe approach to treat intervertebral discs of the thoracic and lumbar spine, while supine decubitus is used for cervical spine treatment.

Before starting the procedure, it is strictly essential to carefully sterilize the area of interest. The skin is carefully disinfected using an iodine solution for proper and extensive cleaning of areas that may come into contact with surgical instruments, and all surgical instruments must be included in a sterile set. Some authors suggest the administration of a pre-procedural antibiotic therapy before treatment but this is optional while others prefer intra-discal antibiotic treatment (25). Before positioning the trocar, local anesthesia is performed by inoculating the anesthetic only into the skin and subcutaneous soft tissues. During the anesthesia procedure it is very important to avoid anesthetizing the nerve root.

Proper trocar positioning varies according to the anatomical region in need of treatment. The DISKOM® device provides different types of needles to be used in different areas; the needle used for the thoracic and lumbar tract has a diameter of 1.55mm (17G) and a length of 160mm. The needle used for the cervical tract has a diameter of 1.15mm (19G) and a length of 80mm.

For lumbar levels, the disc puncture is performed using a posterolateral approach, usually under fluoroscopic guidance. To increase access to the area of the posterior disc space, pillows are placed below the abdomen to keep the lumbar spine in a semi flexed position. The C-arm fluoroscopy is tilted in different ways in order to obtain the "scotty dog view": first it is rotated in the craniocaudal direction along the plane of the disc and then in an oblique way, so that the projection of the articular process is centered in the midpoint of the vertebral body. Then, disc puncture is performed along the x-ray axis, just laterally to the articular process. The needle must slide along the articular process in order to avoid stinging the nerve root in its extraforaminal course. Once the disc has been stitched, both antero-posterior and lateral fluoroscopic projections are needed in order to confirm correct needle positioning (Figure 1).

For thoracic levels, a posterolateral approach under fluoroscopic guidance is preferred. The C-arm is rotated in the cranio-caudal direction on the disc plane and then tilted 35 degrees laterally. In this projection, the base of the rib and the pedicle are projected as two rings. At this point the puncture is performed along the axis of the X-ray beam through the two rings in correspondence with the disc of interest.

For cervical levels, disc puncture is performed with an anterolateral approach. To maximize the width of the anterior portion of the intervertebral space, the neck is kept in a hyperextended position by placing pillows under the upper portion of the thoracic spine. The carotid artery and the jugular vein must be moved laterally by pressing two fingers against the spine. The disc of interest is then pierced by inserting the needle

between the two fingers. On its way, the needle passes between the esophagus medially and the main cervical vessels laterally (Figure 2).

Once the trocar has been inserted and its correct positioning has been assessed, the inner stylet is removed to perform a discography. Discography is performed via a spinal needle to evaluate the configuration of the disc and the integrity of the annulus fibrosus by injecting a contrast medium. This step also allows us a further assessment of the discogenic origin of the pain, as the administration of contrast medium also determines a painful stimulus that must be promptly evaluated during the execution of the discography (Figure 1). This pain stimulation procedure is performed in selected cases, generally in the lumbar tract.

At this point it is possible to proceed with the decompression of the disc by inserting the helical stylet of the discectomy probe (DISKOM®) forward inside the introducer cannula, then the cannula connector can be connected to the collection chamber of the probe. Under fluoroscopic visualization, it is confirmed that the helical section of the stylet protrudes from the distal tip of the cannula by at least one full thread turn, otherwise the cannula connector should be tightened on the discectomy probe.

Once the device has been enabled using the ON button, alternate movements should be made, in particular, it is suggested to alternate continuous anteroposterior movements with circular movements. After about three minutes, the amount of estimated removed disc material approximately varies from 1 to 3 ml and once the time of about 3 minutes has passed, it is recommended to switch off and extract the device, needle and probe cannula included (Figure 3).

Postprocedure Care

In the absence of post-operative complications, patients are observed for a period of about 3 hours during which they must remain on bed rest and are discharged on the same day of the procedure. If necessary, non-steroidal anti-inflammatory drugs and myorelaxant drugs may be prescribed to the patient but it is an option to be assessed in relation to the patient's condition. No lifting of weights, bending, or stooping is permitted for 2 weeks following the percutaneous disc decompression. Patients can return to sedentary or light work after two weeks and are provided with home exercise instructions by a qualified physical therapist.

Complications

The main intraoperative complications that may occur are related to the instrumentation used (e.g., trocar or catheter breakage, nerve root injury) and include bleeding, infections and other general complications. According to the CIRSE classification system, complications are classified into "major" and "minor" (26). The most frequent complication is represented by discitis which, in a certain percentage of cases, can also evolve into epidural abscesses (27,17). Further complications related to the procedure, found less frequently, include allergic reactions to the materials used during the procedure, puncture of dural sac with accompanying headaches, hemorrhages, neurological damage, and pneumothorax in the case of treatment carried out on the thoracic spine and vasovagal reactions in the case of decompression carried out on the cervical tract (28,29,30). In addition, failure of maneuvers, caused by equipment breakage, represents one procedural contingency to be considered (30). Treatment setting, post-operative care and patient follow-up are all actions included in the responsibility of the operator who performed the treatment.

Conclusion

Mechanical disc decompression is a minimally invasive spine intervention that should be considered as an alternative to surgery in properly selected patients. This method can be applied in all segments of the spinal column and involves a lower risk of complications and hospitalization compared to invasive surgical techniques (3,15,18,30,31). It is also useful to underline some peculiar advantages of this technique. In particular, several advantages derive from the fact that a small-sized probe is used; this allows to make a skin incision of only a few millimeters with the consequent

reduction in the risk of causing surgical site infections. It also drastically reduces the risk of causing lesions to the ligamentous system and does not cause any bone modification or reshaping, avoiding any damage to the posterior vertebral arch and adjacent muscle structures. Therefore, after this treatment, the recovery time after the procedure is significantly shorter than the classical surgical approach. Moreover, in order to obtain higher success rates and lower complication rates, correct patient selection and the maintenance of strict sterility during the procedure and adequate patient follow up must always be followed.

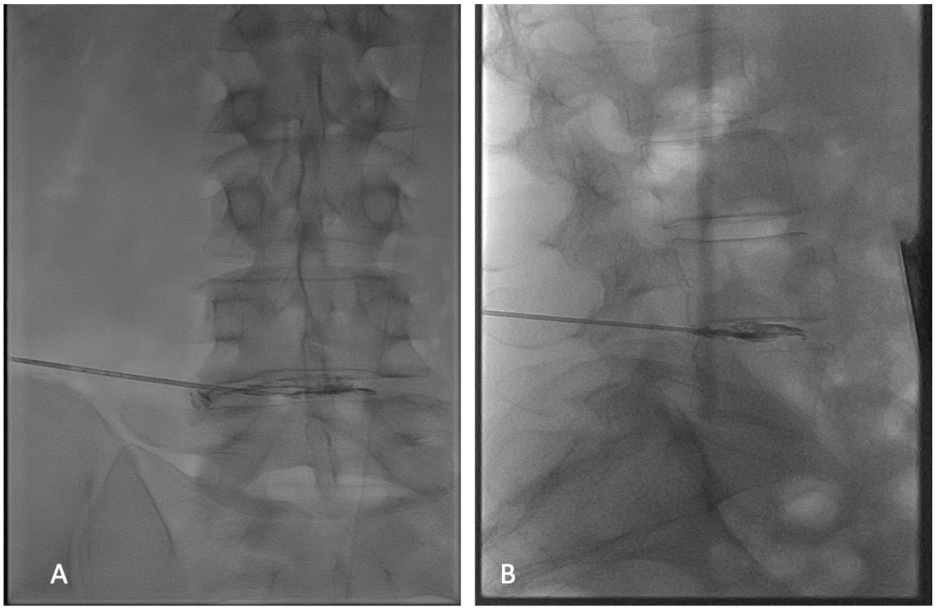

Figure 1. Discography after needle positioning during a L4-L5 discectomy procedure; antero-posterior view A; latero-lateral view B.

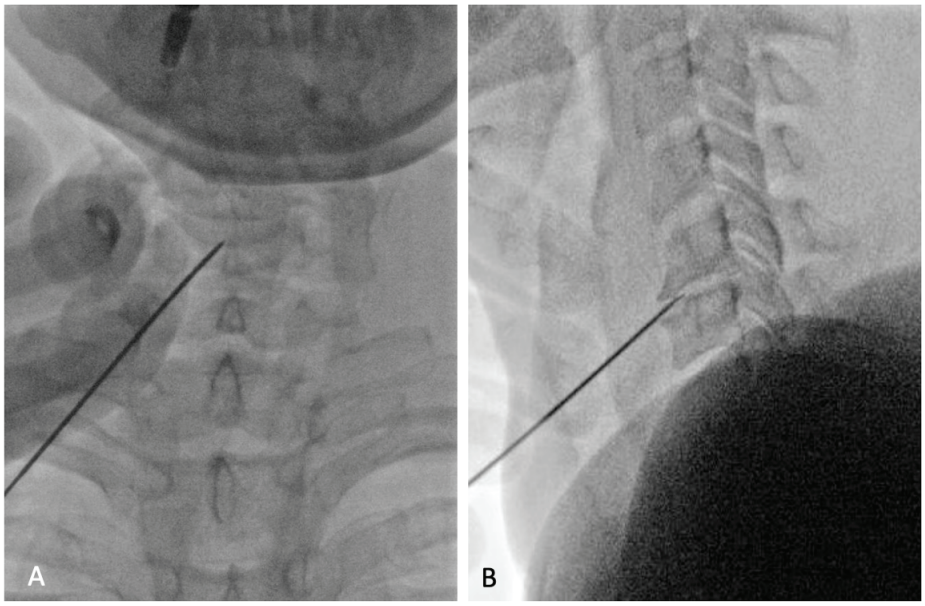

Figure 2. Cervical discectomy procedure on the C5-C6 disc; antero-posterior view A; latero-lateral view B.

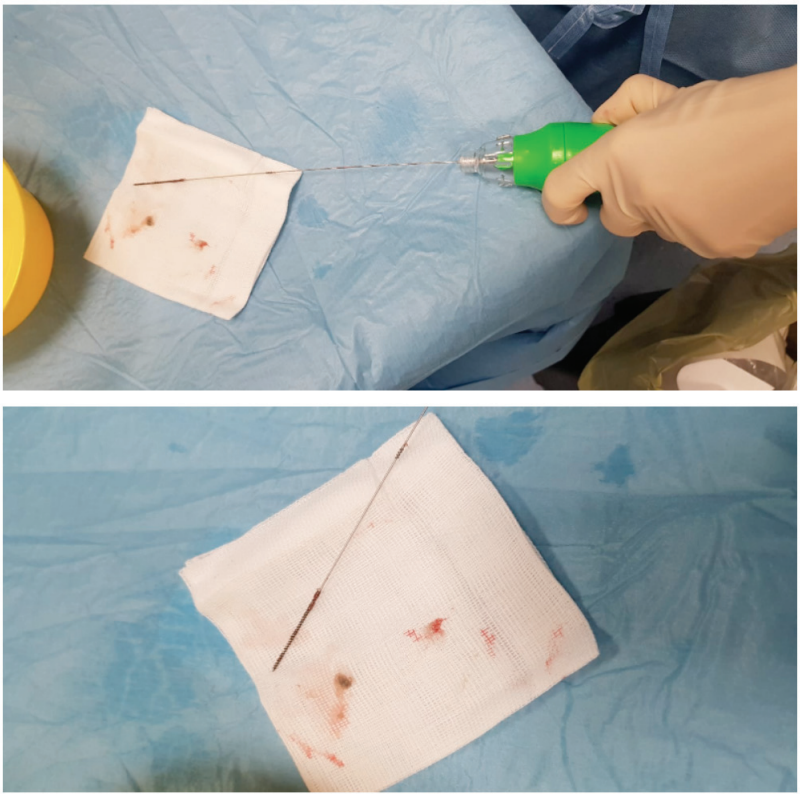

Figure 3. Disc material removed and collected along the probe stylet of DISKOM® probe.

Consent for Publication: Consent for publication was obtained for every individual person's data included in the study.

Human and Animal Rights and Informed: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Informed Consent: Informed consent was obtained from all individual participants included in the study.

Contribution Authors: Each author has contributed to conception and design, analysis and interpretation of the data, drafting of the article, critical revision and final approval.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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