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CIRSE GUIDELINES

Standards of Practice: Quality Assurance Guidelines for Percutaneous Treatments of Intervertebral Discs

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Abstract Percutaneous treatments are used in the therapy of small- to medium-sized hernias of intervertebral discs to reduce the intradiscal pressure in the nucleus and theoretically create space for the herniated fragment to implode inward, thus reducing pain and improving mobility and quality of life. These techniques involve the percutaneous removal of the nucleus pulposus by using a variety of chemical, thermal, or mechanical techniques and consist of removal of all or part of nucleus pulposus to induce more rapid healing of the abnormal lumbar disc. These guidelines are written to be used in quality improvement programs for assessing fluoroscopy- and/or computed tomography-guided percutaneous intervertebral disc ablative techniques.

Keywords Skeletal interventions · Pain management · Musculoskeletal · Spine/nervous system · Pain · Spinal disc herniation

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Introduction

Herniation of intervertebral disc is an important and common cause of low back pain. It affects mobility, physical function, and quality of life, and it costs society much [1, 2]. It is estimated that 70–90% of the normal population will experience at least one episode of sciatica or lumbago during their lifetime [3, 4]. Intervertebral disc and discogenic pain have been identified as causative agents in 26–39% of patients with sciatica or lumbago [3–8]. The long-term outcomes, complications, and occasionally suboptimal results that accompany open disc surgery in herniated discs have led to the development of other treatment techniques that avoid an open surgery through the spinal canal.

Percutaneous treatments are used in the therapy of small- to medium-sized hernias of intervertebral discs to reduce the intradiscal pressure in the nucleus and theoretically to create space for the herniated fragment to implode inward, thus reducing pain and improving mobility and quality of life [9]. These techniques involve the percutaneous removal of the nucleus pulposus by using a variety of chemical, thermal, or mechanical techniques [1, 9–13]. They are based on the study of Hijikata et al. 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" [1]. It consists of removal of all or part of nucleus pulposus to induce more rapid healing of the abnormal lumbar disc.

These guidelines were written to be used in quality improvement programs for assessing fluoroscopy- and/or computed tomography (CT)-guided percutaneous intervertebral disc ablative techniques.

Definition

Percutaneous ablative techniques of intervertebral discs are image-guided therapeutic techniques for intervertebral disc hernia, which use a trocar to puncture the outer annulus of the disc. Through this trocar, a variety of chemical, thermal, or mechanical ablative devices may be placed inside the nucleus pulposus, assuring its partial removal. The nuclear material removal internally decompresses the disc with the least disruption of surrounding tissues.

- *Automated percutaneous lumbar discectomy.* A pneumatically driven, suction-cutting probe within a 2.8-mm outer diameter cannula removes approximately 1–3 g of disc material anterior to the herniation.
- *Intradiscal electrothermal therapy (IDET).* A flexible thermal resistive coil (electrode or catheter) coagulates the disc tissue with radiant heat (electrothermal energy). Although IDET is used for treatment of the annulus and is not a treatment of the nucleus per se, it is included here as an ablative technique for small contained hernias with ruptures of the annulus. Percutaneous intradiscal radiofrequency therapy may be considered an IDET variant where an electrode or catheter applies alternating radiofrequency current to the nucleus pulposus.
- *Percutaneous laser decompression.* Laser energy vaporizes a small volume of nucleus pulposus, thus reducing the intradiscal pressure.
- *Nucleoplasty.* A non-heat-driven process where bipolar radiofrequency energy causes molecular dissociation and dissolves nuclear material creating a series of intradiscal channels.
- *Percutaneous disc decompression.* Nuclear material extraction is achieved with a mechanical device with high rotations per minute and with spiral tips.
- *Ozone therapy.* Ozone's chemical properties and the reaction of hydroxyl radical with carbohydrates and amino acids leads to breakdown of nucleus pulposus, with rapid disappearance of herniated material.
- *DiscoGel.* A chemonucleolytic agent (gelified ethanol) that causes dehydration of nucleus pulposus, thus resulting in retraction of intervertebral disc herniation.

Indications

- Small- to medium-sized contained intervertebral disc herniation confirmed by magnetic resonance imaging (MRI) [12–15].
- Back pain of discogenic origin, sciatica, or crural pain that limit activity for at least 6 weeks (leg pain should be of greater intensity than back pain) [12–14].
- Specific dermatomal pain distribution [16].
- Neurologic findings referring to a single nerve root involvement (positive Lasègue sign; decreased tendon reflex, sensation, motor responses) [13].
- No significant improvement after conservative therapy (6 weeks of bed rest, analgesics, anti-inflammatory drugs, muscle relaxants, physiotherapy) [12, 13]; significant improvement is defined as any pain reduction and mobility improvement of ≥ 4 units on the visual analog scale [17].
- Reproduction of patient's usual pain in the cases in which provocative discography is performed before any percutaneous intervertebral disc ablative technique [12, 14, 15].

Contraindications

Absolute

- Sequestered (free) disc fragment [14].
- Segmental instability (spondylolisthesis) [14, 17].
- Stenosis of neural foramen or spinal canal [14, 18].
- Asymptomatic intervertebral disc bulging discovered as incidental finding in CT scan or MRI [14].
- Untreated, ongoing active infection and/or discitis [12].
- Pregnancy (fetal radiation exposure must be avoided) [15].

Relative

- Hemorrhagic diathesis (should be corrected before the operation) [7, 12].
- Anticoagulant therapy (should be interrupted before the operation) [19].
- Severe degenerative disc disease with more than two-thirds of disc height decrease [16, 20].
- Medical record of intervertebral disc operation at the same level [17].
- Primary or metastatic malignancy.

Patient Selection

Characteristics for the ideal candidate include a single-level, symptomatic, contained disc herniation with leg pain greater than back pain. These candidates do not belong in the most severe surgical disc disease spectrum, and they have a good chance of achieving significant pain reduction with conservative therapy. Therefore, a 4- to 6-week course of conservative treatment should be the first step [14].

Preoperative imaging planning begins with plain films of the spinal column, which are promptly available and inexpensive [20]. These are obtained to provide information about spinal bony elements and possible vertebral misalignment, thus excluding other potential sites and causes of pain origin, including facet arthropathy, spinal canal stenosis, and fracture [21]. MRI with T1- and T2-weighting sequences should be systematically performed before any percutaneous intervertebral disc decompression technique. CT may be performed for a more thorough bone evaluation [20].

Technique

Percutaneous ablative techniques of intervertebral discs are performed under fluoroscopy, CT, or dual (CT and fluoro) guidance with the patient in the prone (when thoracic or lumbar spine is concerned) or in the supine (when cervical spine is concerned) position. Although there are reports of MRI guidance concerning infiltrations of facet joints and selective neural root blocks, this modality is rarely used for the guidance of percutaneous intervertebral disc treatments.

Appropriate preoperative preparation, draping, and strict sterilization of the area of interest are the most important points of these techniques. An iodine solution (the use of extra solution containing alcohol varies among different centers) is used for rigorous and extensive skin disinfection, and all the instruments and materials used (forceps, sterile gauze swabs) should be included in a sterile set. Preprocedural antibiotic therapy administration at least 1 h before the procedure is optional. Some authors prefer intradiscal antibiotic treatment [22].

Trocar positioning is performed under local anesthesia (skin and subcutaneous tissues) to avoid an accidental puncture of the nerve root without patient reaction. The nerve root itself should never be anesthetized.

Trocar Positioning at the Cervical Spine

With the patient in a supine position, under fluoroscopy, the selected disc is recognized and aligned, a projection to the skin is marked, and an antero-lateral approach is performed [1]. Under continuous fluoroscopic control and subluxation of the larynx, advancement of the trocar is performed between larynx and jugular–carotid vessels, until the trocar tip reaches the anterior longitudinal ligament. The right side is usually preferred because the esophagus is located on the left side.

Trocar Positioning at Thoracic Spine

A lateral oblique projection (35°–40° rotation of the tube) is used for disc space definition at the thoracic level [1, 16]. The target point is situated between the superior articulation of the lower vertebral body on the lateral side and the head of the ipsilateral rib on the medial side. Tube rotation greater than 35°–40° may result in costovertebral joint presence that will block the entry point.

Trocar Positioning at Lumbar Spine

Concerning the lumbar spine, intervertebral discs of interest should be aligned in anteroposterior projection [1]. Rotating the tube at 45° will send the spinous process toward the contralateral facet joint, thus producing the "Scotty dog" projection (taking care to preserve the opening of the intervertebral disc's anterior part). Trocar advancement is performed under fluoroscopic control at the Scotty dog projection. Annulus fibrosus puncture can be both felt and seen under fluoroscopy. A curved trocar can be used when necessary for the L5–S1 intervertebral disc [13].

Dual guidance (rotating fluoroscope and CT) provides three-dimensional imaging with exact differentiation of intervertebral disc from the surrounding structures [13].

In general, under every approach and guidance, and for any of the ablative/decompressive devices used (except IDET), the inserted trocar must be inside the nucleus pulposus (projecting in posteroanterior view near the midline) parallel to and at midway between the two end plates. However, the trocar's final position depends on the ablative/decompressive device used [13]. Once the trocar is found in the desired position, any of the above-mentioned devices may be inserted through it. Ablation (either thermal or mechanical) reduces the intervertebral disc volume with no surrounding spinal structures damage. IDET is placed circumferentially in the annulus pulposus, remaining in the midway between the two end plates [12].

Postprocedure Care

In the absence of complications, hospitalization is not necessary. Nonsteroidal anti-inflammatory drugs and muscle relaxants could be prescribed, but this is optional, and practice differs at each center. A follow-up phone call is performed the morning after disc decompression, and the patient is clinically examined 1 week later [15, 23].

Postprocedure restrictions should include rest during the first few days after the procedure, and prolonged sitting positions should be avoided. Heavy lifting, twisting, forward bending, and strenuous body activity are not permitted during the first postoperative period. One week after the procedure, the patient may perform light housework. During the second week, walking and progressive exercise may begin. Weight-lifting is allowed after 3 months [12].

Table 1 Outcome measures of percutaneous intervertebral disc therapies

Method	Success rate	Complication rate
Automated percutaneous lumbar discectomy	75% [32, 33]	Technical failure rate 2.6%
		Mild muscle spasm 9%
		Functional lower limb paresis 0.4% [34]
Percutaneous laser decompression	63–89% [13, 35–37]	Intraoperative 1.1%
		Postoperative 1.5%
		[38, 39]
		General complication rate 0.5–1% [40]
Intradiscal electrothermal therapy	64–75% [12, 28, 41–43]	Transient and mild adverse events (radicular pain, paresthesia numbness) 0–15% [44]
		Serious adverse events (cerebrospinal fluid leak, cauda equine syndrome, vertebral osteonecrosis) <0.5% [44]
		General complication rate from meta-analysis 0.8% [28]
DiscoGel	91.4% [45]	<0.5% [45]
Intervertebral disc nucleoplasty	79% [17]	<0.5% [44]
Ozone therapy	70–85% [46]	<0.5% [47–49]
Percutaneous disc decompression	60–85% [50, 51]	0.5% [20]

Complications

Intraoperative complications are related to the technique itself as well as the instrumentation (e.g., trocar or catheter breakage, nerve root injury). Postoperative complications include bleeding, infection, and other general complications [19]. Discitis is the most common complication of percutaneous disc decompression techniques, occurring in up to 0.24% per patient and 0.091% per disc of patients followed in sequence of appearance by epidural abscess [14, 23–28]. Less frequently encountered complications of the technique include reflex sympathetic dystrophy, puncture of thecal sac with accompanying headache, hemorrhage and neurologic injury, allergic reactions to any of the agents used during the procedure, pneumothorax (in case of thoracic intervertebral disc decompression), and vasovagal reactions (in case of cervical intervertebral disc decompression) [13, 23–25, 29]. In addition, material failure resulting from open surgery has been described [30]. Finally, there is a case of cauda equine syndrome reported by Onik et al. due to improperly placed nucleotome, but this was related to an interlaminar approach [31] (Table 1).

Qualification and Responsibilities of Personnel

Percutaneous ablative techniques of intervertebral discs should be performed by an experienced interventional radiologist adequately trained in the procedures. The preprocedure setup, the postprocedure care, and the patient's follow-up are all included in the operator's general responsibilities. Proper patient selection, strict sterility maintained during the procedure, adequate follow-up, and patient's compliance with the restrictions placed on him will result in higher success rates and lower complication rates.

Conflict of interest The authors declare that they have no conflict of interest.

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