## HOW IS IT USED?

### TRIALING

- Place the electrodes with the pads placed around the painful area.
- With the TENS connected and turned on, a sensation should be felt covering the painful area.
- Use the electrical stimulus pattern that by trial and error is found to be the most successful in decreasing pain. This is usually the high-frequency, low-intensity mode.
- With this mode the intensity is increased until a buzzing or tingling sensation is felt.
- The intensity is then reduced until it is barely felt.
- Continue this for 20–30 minutes.
- If the pain is decreased, 30 minutes or more of stimulation can be given.
- If there is no decrease in pain, move the pads to cover nearby trigger points or acupuncture points and retry the stimulation for an additional 20–30 minutes.
- If pain is felt along a nerve distribution, try placing the electrodes on the skin directly over the nerve.

### LONG-TERM USE

- There are minimal side effects from the skin pads or use of the current.
- Tolerance may occur in the first few months with loss of efficacy.

## HOW MUCH DOES IT COST?

- The medical insurance company usually covers the leasing and subsequent costs.
- Purchase costs are $350 to $400, with ongoing costs for renewing the pads and electrode wires.

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# 76 DISCOGRAPHY/INTRADISCAL THERMAL THERAPIES


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## DISCOGRAPHY

### CONCEPTS

- Discography is a provocative diagnostic test that attempts to evoke and reproduce the patient's typical pain, by injection of contrast medium into the nucleus of the intervertebral disc.
- Current concept of the discography relies on the assumption that evoked pain is a result of two pathways affecting intradiscal nerve endings: a chemical stimulation of sensitized disc tissue and a mechanical stimulus resulting from fluid-distending stress.
- Increased intradiscal pressure within a diseased disc is thought to stimulate over-sensitized nociceptors in the annulus fibrosis or/and the nerve endings within the pathologically innervated annular fissures.
- The test endeavors to confirm or refute the hypothesis that a particular disc is a source of patient's familiar (concordant) pain.
- Discography is an interventional procedure recommended only when other less invasive diagnostic tests are inconclusive.
- When combined with CT-discography, this test can also provide unique morphologic characteristics of the disc structure and degrees of annular and endplate disruption.
- Additional value of discography is in identification of asymptomatic discs. When a single disc is found to be symptomatic in the presence of adjacent asymptomatic discs, focused surgical therapy can be entertained.

- Although the diagnostic power of discography still remains controversial, when performed correctly, it is a relatively safe and sensitive test for identifying painful discs, which may predict therapeutic outcomes of surgical or other interventional treatments and may help patients avoid unnecessary surgical interventions.
- As a provocative test, discography is liable to false-positive results, which can be potentially lowered (to an acceptably low 6% rate), by adherence to strict operational standards, interpretation criteria, and proper patients selection.
- Discography is the diagnostic gold standard for diagnosing or excluding discogenic back pain.

## DISCOGENIC PAIN

- Although the external outline of the disc may remain intact, there are many pathologic processes, including annular tears, degeneration, endplate injury, and inflammation, that can cause sensitization and stimulate pain nociceptors within the disc itself, independent of nerve-root stimulation symptoms.
- In a diseased disc, pain may be generated from deep within its own tissue, beyond normal innervation of the outer third of the annulus, with pain-carrying nerve fibers extending deep inward into the middle annulus and even deeper inward. This has been observed in degenerative discs, and has been linked to the discogenic back pain syndrome.
- Discogenic low back pain is considered to be one of the most common causes of chronic low back pain, accounting for approximately 26%–39% of its incidence.
- Pain response involves complex mechanisms, including amplification of the pain in the sensitized, diseased disc, through the secretion of pro-inflammatory mediators, including substance P, inflammatory cytokines, calcitonin gene-related peptide (CGRP), vasoactive intestinal peptide (VIP), tumor necrosis factor-alpha (TNF-a), nitric oxide, matrix metalloproteinases (MMPs), and increased number of mechanoreceptors and pain-producing neurons.
- Distinct from normally aging discs, "pathologically painful" discs show a process of neo-innervation extending along anular fissures as well as to the inner anulus and even nucleus pulposus, which likely explains the pain of provocation discography.
- Discogenic back pain is typically a "diagnosis by exclusion" when other potential sources of back pain have been eliminated.
- History, physical examination, and imaging studies have limited specificity for discogenic back pain, but can help navigate a diagnostic algorithmic process, and, most importantly, can help rule out and screen for potentially serious and rare spinal disorders.

## INDICATION CRITERIA

- To test a diagnostic hypothesis of discogenic origin of pain when other sources of back pain have been eliminated in patients who failed conservative treatment lasting longer than four months.
- To confirm diagnosis of discogenic pain and to specify the exact levels of symptomatic discs when considering invasive intradiscal treatment options, including spinal fusion.
- To assess back or neck pain in patients with minimal or no findings on imaging studies, such as MRI or CT scan, and to analyze disc morphology.
- To determine symptomatic disc levels in patients with multilevel disc abnormalities on imaging studies.
- To identify normal and nonsymptomatic discs to minimize a chance of unnecessary surgical intervention.

## CONTRAINDICATIONS

### *Absolute*

- The patient is unable or unwilling to consent to the procedure, or to cooperate.
- Inability to assess patient response during the procedure.
- Untreated systemic or localized infections.
- Pregnancy.

### *Relative*

- Allergy to contrast medium, local anesthetic, or anitibiotics.
- Anticoagulants or bleeding diathesis.
- Any psychological or anatomical problems that could compromise safety and success of the procedure (including spinal cord compromise and/or myelopathy at the level of proposed discography).

## EVALUATION

- The patient response to disc stimulation needs to be accurately monitored, and include: the presence or absence of pain, the VAS score of the pain, the pressure at which the pain was produced, and concordance of pain.
- If the patient's pain intensity, location, and a character of pain during the disc provocation are similar to or

the same as the patient's typical, accustomed pain, the criteria for concordant pain are satisfied.

- A true positive response is concordant pain, ≥7/10, sustained for greater than 30–60 seconds, at a pressure of <50 psi above opening, volume ≤3.5 mL, and a presence of at least one negative control disc.
- Without an asymptomatic "control disc," there is no evidence that the patient can discriminate between a symptomatic and an asymptomatic discs, especially in case of multiple concordant pain levels.
- Most abnormal discs will be painful between 15 and 50 psi a.o. and are termed "mechanically-sensitive" based on a four-type classification introduced in the 1990s by Derby et al in respect to annular sensitivity. Discs which are painful at pressures <15 psi a.o. are termed low-pressure positive or "chemically-sensitive" discs; if discs are painful between 15 and 50 psi a.o., they are termed "mechanically sensitive" discs. Indeterminate discs are painful between 51 and 90 psi a.o., and normal discs are not painful on provocation.
- The degree of radial and annular disc disruption is commonly described using modified Dallas discogram scale. Grade 0 describes contrast contained within the nucleus pulposus; grades 1–3 describe degree of fissuring extending to the inner, middle, and outer annulus, respectively; grade 4 describes a grade 3 annular fissure with a greater than 30 degree circumferential arc of contrast; a grade 5 involves spread of contrast beyond the outer annulus on post-discography CT images.

## LUMBAR DISCOGRAPHY

- Lumbar discography is usually approached posterolaterally, although lateral (extrapedicular), posterior, and midline approaches may be employed (Figure 76-1).
- Light sedation is advisable only during needles placement, and patient has to be responsive during the testing part of the procedure.
- Double needle approach is recommended to minimize the risk of disc infection and to assist in the needle placement technique (particularly at the L5–S1 interspace).
- The discography needle has to be ideally positioned within 4–5 mm of the center of the nucleus on both AP and lateral fluoroscopy views. An annular injection may give a false-positive, false-negative, or misleading pain response.
- Once the tip of needle has been properly placed in the center of the disc, contrast medium mixed with antibiotic is injected into each disc at slow velocity, using preferably a controlled injection syringe with digital pressure readout. Slow injection spead (~0.1 cc/s) is crucial to reduce false-positive findings.

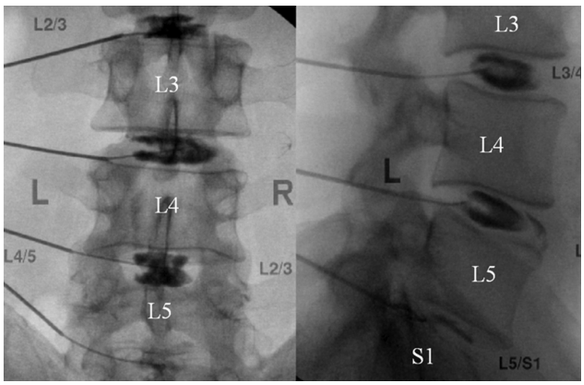


**FIG. 76-1.** Provocative Discography procedure at the L3–4, L4–5, and L5–S1 discs (AP and lateral fluoroscopy images). The L3–4 and 4–5 level discs exhibit a normal nucleus with bilobed "hamburger" patterns of contrast spread. The L5–S1 disc shows signs of disc degeneration with a contrast spread involving the nucleus pulposus with a relatively intact anulus fibrosus.

- Injection continues until one of the following endpoints is reached: pain response ≥7/10, intradiscal pressure >50 psi a.o. above opening in a disc with a grade 3 annular tear or 80-100 psi a.o. with a normal-appearing nucleogram, epidural or vascular pattern is evident, or a total of 3.5 mL of contrast has been injected (some severely degenerated discs may accept greater volume; however, the incidence of false-positive pain responses may increase).
- Typical opening pressures are 5–25 psi a.o., depending on the degree of nuclear degeneration; if it exceeds 30 psi a.o., this usually indicates that the needle tip is lodged within the inner anulus, and needs to be repositioned.
- A variety of patterns occur in abnormal discs, whereas the normal nucleus assumes a globular or bilobed ("hamburger") pattern. However, none of these patterns are indicative of discogenic pain. (See Figure 76-1).
- Positive diagnosis can be ascertained only by the patient's subjective response to disc injection.

## CERVICAL DISCOGRAPHY

- Cervical discs are embryologically and morphologically different from lumbar discs and the pathology of painful cervical discs remains elusive.
- Besides the usual risks of discography, a cervical discography has the added risk of clinically significant hemorrhage, myelopathy, and esophageal puncture. A risk-benefit analysis prior to performing this procedure is highly advisable.
- During discography, the patient lies supine on the fluoroscopy table with gentle neck extension. As the

esophagus lies to the left in the lower neck, the right-sided approach is preferable. Firm but gentle pressure applied at the point of needle insertion to displace the great vessels laterally and the laryngeal structures and trachea medially.
- The needle is advanced slowly into the substance of the disc under direct fluoroscopic visualization. Once the needle is passed several millimeters into the disc, the lateral view is recommended to guide further advancement, taking precaution to not pass the needle through the disc and into the epidural space or spinal cord.
- Once the tip of the needle has been correctly placed in the center of the disc, manual syringe pressure is increased slowly. Concordancy and pain intensity are recorded at the time of distention and at 0.1–0.2 mL increments. The volume of dye that the disc accepts should be noted. A normal cervical disc offers firm resistance and accepts 0.25–1.0 mL of solution.

### COMPLICATIONS

- Vasovagal reactions, especially for cervical discography.
- Needle misplacement can result in penetration of the viscera and pneumothorax, arterial puncture, and damage of nerve roots, thecal sac puncture, and headaches.
- Infection is usually inocculated from skin surface organisms or midadventure through bowel perforation, and may involve epidural abscess, retropharyngeal abscess, and discitis and osteomyelitis.

### PREVENTION OF DISCITIS

- To avoid infection, stringent attention to aseptic technique is critical. All the procedures should be performed under sterile conditions with double gloves.
- The causative organisms of discitis are typically *Staphylococcus aureus, Staphylococcus epidermidis*, and *Escherichia coli*.
- Prophylactic intravenous antibiotics (cefazolin 1 g, gentamicin 80 mg, clindamycin 900 mg, or ciprofloxacin 400 mg) are given right before the procedure.
- Along with IV antibiotics, many discographers mix antibiotics with contrast dye (between 1 and 6 mg/mL of cefazolin or an equivalent dose of another antibiotic) for intradiscal administration.

### VALIDITY

- As a provocative test, discography has been criticized to have a potentially high false-positive rate. The reasons for that could be due to technical errors, due to neurophysiological phenomena, or due to psychosocial factors.
- Recent advances in discography technique, including use of pressure-controlled manometry and adherence to strict diagnostic criteria, help improve validity of this test significantly. If strict criteria are applied, lumbar discography is very specific in subjects with normal psychometric profiles without chronic pain.
- A recent meta-analysis of studies of asymptomatic subjects undergoing discography showed a high specificity of 0.94 (95% CI 0.89–0.98) and a relatively low false-positive rate of 6%.

### UTILITY

- In patients with chronic intractable neck or back pain but negative or indeterminate imaging findings who are being considered for surgical intervention, discography can help localize the symptomatic level and potentially benefit patients by surgical intervention or help avoid an unnecessary intervention in case of negative discography results.
- Discography is an invasive test that can be associated with short- and long-term risks. When indicated and correctly performed, it is a safe and sometimes powerful complement to the overall clinical context and not intended to be a stand-alone test.

## INTRADISCAL THERMAL THERAPIES

### CONCEPTS

- Intradiscal thermal therapies refer to a group of percutaneous interventions that deliver heat energy to the intervertebral disc with the goal of reducing chronic back pain of discogenic origin.
- Inflammation, anatomic derangement of the disc tissue and abnormal disc mechanics are considered to be possible etiologic factors in developing discogenic back pain.
- Thermal destruction of nociceptive fibers, shrinking subannular disc protrusions, sealing annular tears, improving delaminated annular tissue by collagen modification, and stimulation of healing response have been proposed mechanisms of intradiscal thermal therapies in an attempt to alleviate discogenic pain. Scientific evidence to support such mechanisms of action in the literature is lacking
- The heat delivered with these therapies can be generated through a variety of means, including electrocautery, thermal cautery, laser, and radiofrequency energy. Variety of radiofrequency (RF) probes and catheters as well as resistive heating coils (such as

IDET, or intradiscal electrothermal therapy) have been developed and used.

- Most intradiscal thermal treatments are performed using radiofrequency energy, which may be applied with unipolar or bipolar probes, passed through an introducer needle into the outer postero-lateral annulus or passed across the posterior annulus.
- Bipolar probes are thought to allow for greater control and focus of the energy. One of the newer methods of increasing size or volume of the lesion is by cooling the RF electrodes internally, called intradiscal biacuplasty (IDB) procedure.
- Strict selection of patients with specific discogenic pain, possibly confirmed by provocative discography test, may improve results of intradiscal thermal therapies, and provide patients with minimally invasive approach, potentially avoiding spinal fusion surgery.

## THEORY

- The precise mechanism of action of intradiscal heating in helping patients with back pain is unclear.
- Tissue modulation, including shrinkage, denaturation, and structural changes to collagen fibers in the annulus to increase annular stability and disc biomechanics, are some of the proposed hypothesis.
- Another possible mechanism of action is denervation of ingrown nociceptors by neuroablation of the posterior annulus and elimination of transmission of pain symptoms from the denervated disc.
- Targeted thermal therapy can induce collagen fibril shrinkage at temperatures greater than 60°C and destruction of neural tissue at temperatures above 42°C to 45°C.
- The typical IDET procedure can generate only sufficient heat to produce nerve ablation. Collagen modification may not be a primary effect.
- Current protocols might not cause either fissure closure or improved disc stability.
- The histologic findings are denaturation, shrinkage, and coalescence of annular collagen and stromal disorganization after IDET.

## PROCEDURES

- Most intradiscal thermal therapy procedures target the outer and posterior annulus of the disc, using number of devices that deliver heat energy. The procedures are completed under fluoroscopy and minimal sedation.
- IDET uses a fluoroscopically guided intradiscal catheter inserted into the nucleus and circumferentially navigated to the outer annulus and heated using either electrothermal energy or radiofrequency energy (RFE). The heating coil in the distal 5 cm of the catheter is heated to 90°C for 16–17 minutes. Proper catheter position is one of the key elements to obtaining good results. (Figure 76-2)
- Intradiscal radiofrequency treatment (IDRT) targets the outer annulus using an electrode passed through an introducer needle inserted into the outer posterior lateral annulus and passed across the posterior annulus.
- Cooled bipolar RFE or intradiscal biacuplasty (IDB) procedure uses a bipolar system that includes two radiofrequency probes placed on the posterolateral sides of the annulus 2.5–3 cm apart, and cooled using circulating water pumped through a cannula. The probes are heated to 45°C for 15 minutes while water is continuously circulated around the probes. The heating is typically less painful than heating using the IDET catheters (Figure 76-3).

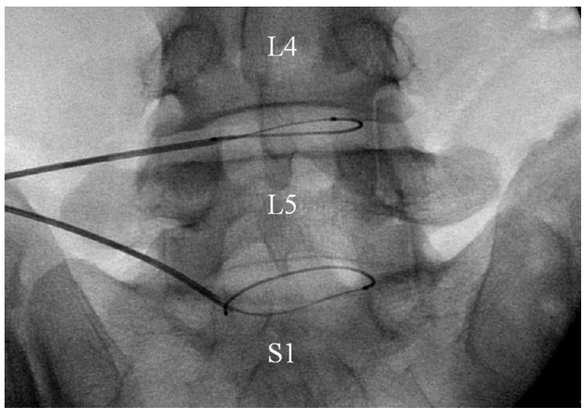


**FIG. 76-2.** IDET procedure (AP fluoroscopy image). The eletrothermal wires are positioned within the L4–5 and L5–S1 discs.

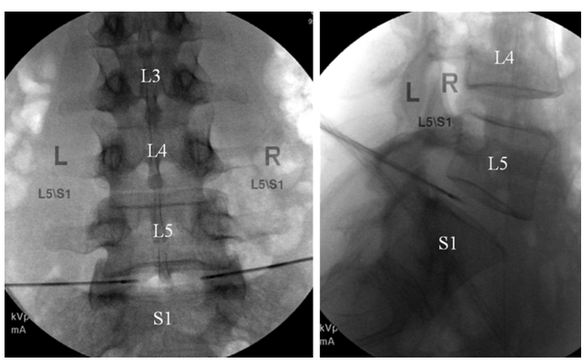


**FIG. 76-3.** Biacuplasty procedure (AP and lateral fluoroscopy images). Two water-cooled radiofrequency electrodes (Baylis Medical, Inc.) are placed on the posterolateral side of the annulus within the L5–S1 disc.

- Cooled RFE electrodes are thought to increase the lesion size and facilitate ablation when compared with standard RFE electrodes, whereas linear placement of the two electrodes makes the procedure easier to perform.
- The patient must be alert enough to be observed for the development of radicular pain during the procedure.
- To prevent discitis, the most serious potential complication of the procedures, pre-procedural intravenous antibiotics, and intradiscal antibiotic injection after heating (2–20 mg cefazolin) is recommended.

### INCLUSION CRITERIA

- Unremitting, chronic axial low back pain of at least six months of duration.
- No improvement with aggressive nonoperative care.
- Absence of neural compressive lesions on MRI as well as instability or stenosis.
- Positive discography test with reproduction of concordant pain at low pressurization at one or two intervertebral disc levels.
- Preservation of greater than 50% of the disc height.

### EXCLUSION CRITERIA

- Greater than 50% disc height loss.
- Major psychological impairment.
- Pregnancy.
- Extruded or sequestered herniation.
- Moderate to severe spinal stenosis and spondylolysthesis.
- Nerve root compression with motor deficit.
- Medical or metabolic disorder that would preclude appropriate follow-up and participation, as well as systemic infection and inflammatory arthritis.
- Prior surgery at the symptomatic level(s) (as a relative contraindication).

### OUTCOMES

- The current peer-reviewed literature report conflicting evidence regarding the effectiveness of intradiscal heat treatments for chronic discogenic back pain.
- Two published randomized controlled trials (RCTs) evaluated annular heating using the IDET method. One found no effect of either the sham or IDET procedure; the other found statistical improvement in IDET group compared to sham control in VAS scores and the 36-item Short-Form Health Survey (SF-36), particularly in physical function, bodily pain, and sitting tolerance scores.
- There is a weak support in favor of using IDET over continued conservative care.
- Recent randomized placebo-controlled study of biacuplasty for treatment of discogenic pain showed statistically significant improvements in physical function, pain, and disability at six months follow-up as compared to sham group. Observational study showed a 50% decrease in VAS scores in 50% of patients at six months follow-up.
- Even though there is a lack of evidence that intradiscal heating is effective, it is significantly less invasive than conventional surgical options and may, therefore, be beneficial for a small subset of patients who fail to improve after conservative therapy or who are not appropriate surgical candidates.

### COMPLICATIONS

- Serious complications following percutaneous intradiscal thermal procedures are infrequent.
- Possible complications include:
  - Catheter breakage (0.05%)
  - Nerve root injury
  - Discitis (0%-1.3%)
  - Osteonecrosis of the vertebral body
  - Epidural abscess
  - Acute lumbar disc herniation (0.3%)
  - Cauda equina syndrome

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# 77 MINIMALLY INVASIVE LUMBAR DISC DECOMPRESSION

*Ramsin Benyamin, M.D.*

## INTRODUCTION

Percutaneous lumbar disc decompression (PLDD) refers to several techniques that are utilized for disc material extraction of patients with disc herniations. Mixter and Barr first described the surgical treatment for intervertebral disc ruptures in 1934 and since then, open surgical procedures for discectomies have become a popular procedure, despite the limited evidence to support its efficacy. Hemilaminectomies and discectomies were initially performed to address the pain and symptoms of intervertebral disc herniations. Open microdiscectomies that involve the dilation of paraspinus muscles, rather than stripping the muscles followed as an alternative technique to reduce morbidity rates. Minimally invasive percutaneous procedures for disc decompression were then developed as a less invasive way of performing microdiscectomies. This approach yields less tissue damage and has faster recovery times.

Pain as a result of disc herniations is likely due to ventral compression and vascular ischemia of nerve roots. The PLDD procedures are best suited for contained disc herniations with radiculopathy. Complications arise and the treatment can be less effective if used on uncontained disc herniations, patients who have narrowed