Discography, IDET, Percutaneous Discectomy, and Nucleoplasty: Complications and Their Prevention

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ABSTRACT

Objective. The ability to access the intervertebral disk percutaneously using image guidance has proven to be a safe approach that allows for diagnostic and therapeutic interventions within the nucleus pulposus. Among the most common techniques currently in use are discography, intradiscal electrothermal therapy (IDET), and nucleoplasty; complications have been described but are uncommon. The objective of the current manuscript is to review the available literature regarding complications associated with these intradiscal techniques.

Design. This report describes a patient with chronic low back pain associated with lumbar degenerative disc disease who is a typical candidate for diagnostic discography and treatment with intradiscal approaches. In the current manuscript, the available reports detailing complications associated with each of these techniques are reviewed, and recommendations for prevention are outlined.

Conclusions. All of these techniques share the common element of introducing a cannula into the nucleus pulposus using a percutaneous approach, and direct trauma to the spinal nerve can occur. Likewise, bleeding and infection can follow the introduction of the cannula. With any of these intradiscal techniques, discitis is an inherent risk, a delayed and insidious infection within the disk space that can be difficult to diagnose and treat. The thermal wire used to perform IDET is subject to mechanical breakage, and the thermal energy delivered during both IDET and nucleoplasty can cause direct thermal injury to neural elements when incorrectly positioned. With use of prophylactic antibiotics, sterile technique, and disciplined use of image guidance, the incidence of these complications can be minimized.

Key Words. Complications; Discography; Intradiscal Electrothermal Therapy (IDET); Nucleoplasty

Overview

The ability to access the intervertebral disk percutaneously using image guidance has proven to be a safe approach that allows for diagnostic and therapeutic interventions within the nucleus pulposus. Lumbar discography is a controversial diagnostic test that has seen resurgence in popularity in recent years. Recent modifications incorporating measures of intradiscal pressure into the diagnostic algorithm appear to offer some promise of improving the diagnostic accuracy of discography for identifying symptomatic disks [1]. Until the last several years, the role of discography was solely to identify the intervertebral disk or disks that were causing a given patient’s pain, thereby allowing the surgeon to rationally plan surgical fusion. In recent years, discography has
been used to identify symptomatic disks prior to minimally invasive intradiscal procedures for treating discogenic low back pain and contained disk herniations.

Intradiscal electrothermal therapy (IDET) is a recently introduced technique that employs a steerable thermal resistance wire inserted into the intervertebral disk through a rigid cannula (SpineCATH, Smith & Nephew, Andover, MA). Using radiographic guidance, the catheter is placed along the medial border of the posterior annulus fibrosus. Thermal energy is then applied using a standardized heating protocol. In experimental animals, this approach has been shown to destroy penetrating nociceptive fibers and to change the cross-linking of glucosaminoglycans, thereby stiffening the intervertebral disk [2]. Clinical studies have been mixed, with two recent, high-quality randomized controlled trials: one demonstrated significant efficacy in pain reduction and improved function in about one-third of treated patients [3] while the other demonstrated no effect [4]. On balance, the available literature suggests a modest overall reduction in pain and improvement in function in less than half of patients receiving IDET at a single level who have concordant discography and well-preserved disk height [5]. The usefulness of IDET has only been demonstrated for the treatment of symptomatic degenerative disk disease causing axial low back pain.

The use of percutaneous techniques for treatment of radicular pain associated with contained disk herniations has also developed rapidly in recent years. A range of different techniques has been developed that all rely on the same principle: for treatment of radicular pain (primarily leg pain) associated with a disk bulge or contained disk herniation, a cannula is introduced into the nucleus pulposus, and one of several techniques is used to remove a portion of the central portion of the intervertebral disk [6]. The idea is that by removing a portion of the central disk, the pressure within the disk can be reduced, thereby allowing the protruding disk to fall away from the spinal nerve. A number of techniques has been developed to allow for percutaneous discectomy, including chemonucleolysis with chymopapain, laser discectomy, automated percutaneous lumbar discectomy (mechanical removal of a portion of the disk using a cutting and/or suction device), and nucleoplasty using a technique called Coblation to vaporize a portion of the disk. Chemonucleolysis using chymopapain has undergone extensive testing; a recent meta-analysis demonstrated that chemonucleolysis is superior to placebo for treating radicular pain associated with disk herniations; however, treatment outcomes were inferior to those who received microsurgical discectomy [7]. A significant proportion of patients undergoing chemonucleolysis required repeat discectomy within 2 years, and the results of subsequent discectomy were inferior to those who received primary microsurgical discectomy. A number of other techniques for performing percutaneous discectomy are available. One such technique is called nucleoplasty and employs a technology called Coblation (Arthrocare Corporation, Austin, TX) [8]. Coblation uses radiofrequency energy to excite the electrolytes in tissue, creating a precisely focused plasma. The plasma’s energized particles have sufficient energy to break molecular bond within tissue, causing tissue to dissolve at relatively low temperatures (typically 40°C to 70°C). The result is volumetric removal of target tissue with minimal damage to surrounding tissue. When Coblation is applied to remove tissue within the nucleus polposus (“nucleoplasty”), intradiscal pressure is reduced in experimental animals [9]. Although nucleoplasty is in widespread clinical use, validation of the efficacy of this approach to percutaneous discectomy is still emerging.

Complications associated with discography, IDET, and nucleoplasty have been described but are uncommon. All of these techniques share the common element of introducing a cannula into the nucleus pulposus using a percutaneous approach (Figure 1), and direct trauma to the spinal nerve can occur. Likewise, bleeding and infection can follow the introduction of the cannula. With any of these intradiscal techniques, discitis is an inherent risk, a delayed and insidious infection within the disk space that can be difficult to diagnose and treat. The thermal wire used to perform IDET is subject to mechanical breakage, and the thermal energy delivered during both IDET and nucleoplasty can cause direct thermal injury to neural elements when incorrectly positioned.

Case Presentation

A 34-year-old gentleman presents with a 3-year history of axial low back pain. He is a construction worker and has been unable to work for more than 2 years due to the pain. The pain began insidiously without any specific injury. Despite conservative therapy with oral analgesics and several courses of
physical therapy, his pain has remained debilitating. Magnetic resonance imaging of the low back demonstrates loss of disk hydration that is isolated to the L4/5 level. He is referred for diagnostic discography. During the course of discography, his typical pain is reproduced at the L4/5 level with minimal pain at adjacent levels. The procedure concludes uneventfully. Three weeks following the discogram, the patient calls to report worsening low back pain.

Lumbar Discography

Complications

Complications associated with lumbar discography range from exacerbation of pain to spondylodiscitis (Table 1). All complications associated with discography can also be expected with any of the other intradiscal treatments, as placement of a needle or cannula into the nucleous pulposus of an intervertebral disk is common to all of these procedures (Figure 1). En route from the skin’s surface to the intervertebral disk, the needle or cannula must pass inferior and medial to the spinal nerve just inferior to where the nerve root traverses the intervertebral foramen. Although direct trauma to the spinal nerve typically produces only a transient paresthesia, persistent neuropathic pain can result. Bleeding within the subcutaneous tissues or paraspinal musculature can result in significant hematoma, which is typically self-limiting. Likewise, infection within the superficial and deep paraspinal tissues can occur as the result of needle placement for discography or cannula placement for intradiscal procedures.

Spondylodiscitis

Spondylodiscitis, infection within the disk space, is a well-recognized complication of diagnostic discography, with an overall incidence of less than 0.15% per patient and less than 0.08% per disk injected [10]. Discitis appears to result from infection introduced by the needle tip [11]. The most common organisms identified are Staphylococcus aureus and Staphylococcus epidermidis [11].

Diagnosis and Management of Discitis

Discitis is an insidious infection that presents initially with worsening back pain. The clinical pre-

![Figure 1](https://academic.oup.com/painmedicine/article-abstract/9/suppl_1/S73/1825717)

**Table 1** Complications associated with intradiscal procedures

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<tr>
<th>Complications associated with intradiscal needle or cannula placement</th>
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<tr>
<td>Hematoma</td>
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<td>Superficial abscess</td>
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<td>Deep abscess (paraspinal)</td>
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<td>Allergic reaction to radiographic contrast or antibiotic</td>
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<td>Direct needle trauma to a spinal nerve with transient or persistent paresthesia</td>
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<td>Spondylodiscitis</td>
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<th>Complications associated with electrothermal treatment</th>
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<td>Thermal injury to a spinal nerve</td>
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<td>Epidural placement of IDET catheter resulting in thermal injury to the cauda equina</td>
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<td>Fracture of the IDET catheter resulting in retained intradiscal catheter fragment</td>
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<td>Vertebral osteonecrosis</td>
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<td>Disk herniation</td>
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IDET = intradiscal electrothermal therapy.
sentation and time course are highly variable. A detailed discussion of the diagnosis and management of discitis is beyond the scope of this manuscript, but is available in several recent review articles [12,13]. Early in the course of discitis, there are few systemic symptoms, as the disk space is poorly vascularized, and systemic bacteremia is uncommon. In a series of 29 consecutive patients with spontaneous disk space infections, 10 patients (34%) had an elevated serum leukocyte count, and 21 patients (72%) had an elevated erythrocyte sedimentation rate [13]. Diagnosis is dependent on maintaining a high index of suspicion and is confirmed by characteristic changes seen within the disk space on magnetic resonance imaging [14]. Practitioners should suspect discitis in patients who report worsening back pain during the weeks following discography, particularly a change in the pattern of long-standing back pain. Successful conservative treatment of discitis relies on early detection [13]. Pain practitioners should establish written postprocedural guidelines for their patients that include a clear description of the signs and symptoms of evolving infection and a clear process for contacting pain clinic personnel to report the appearance of any worrisome signs or symptoms. Practitioners performing discography should be familiar with the principles of diagnostic evaluation and management of the patient with discitis.

**Prevention**

Animal studies suggest that both intravenous and intradiscal administration of antibiotic prophylaxis can prevent the development of discitis even when bacteria are directly introduced into the disk [15,16]. Because discitis can be classified as potentially catastrophic, the 1999 Centers for Disease Control (CDC) and Prevention Guideline for Prevention of Surgical Site Infection supports the use of routine antimicrobial prophylaxis during discography and other intradiscal treatment techniques [17]. There are only limited animal data available to guide the selection of antimicrobial agent and the route of administration for prophylaxis during discography and intradiscal treatments. Discography is commonly carried out with use of radiographic contrast material injected into the intervertebral disk; cefazolin and clindamycin both remain active in vitro when mixed with radiographic contrast (iohexol) [16]. Extrapolation from animal data [15,16] and the CDC recommendations [17] support the routine use of intradiscal or intravenous antibiotics prior to discography and other intradiscal techniques (Table 2); the advantage of one route of administration over another is not clear.

**IDET**

**Complications**

Similar to any intradiscal technique, transient paresthesia and exacerbation of back pain in the first several days following treatment are common and an expected part of IDET. Indeed, back pain may increase, requiring treatment with oral analgesics. The increase in pain level typically returns to the preoperative or to a better level of pain within several days to weeks following treatment.

Published cohort trials have indicated that the studied patients had experienced no IDET-related complications [18–23]. Nonetheless, sporadic case reports have appeared of thermal injury to the cauda equina, disk herniation, and osteonecrosis of the vertebral endplates following IDET (Table 1).

Transient nerve injury appears to be the most common complication associated with IDET. In most of these circumstances the operator has reported nerve contact at the time of intradiscal needle placement with the affected nerve. Thermal injury to the nerve root may be possible, particularly if catheter placement is not entirely within the disk. To date, there are no reported cases of thermal nerve root injury that remained permanent in cases where the catheter was within the confines of the disk.

A recent analysis of the Food and Drug Administration Medical Device Reports found 21 cases of catheter breakage [24]. Two were removed percutaneously and one was excised at the time of disk

<table>
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<th>Table 2</th>
<th>Antimicrobial drugs of choice for prophylaxis during discography and other intradiscal treatment techniques</th>
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<tr>
<td><strong>Drug</strong></td>
<td><strong>Dose</strong></td>
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<tr>
<td>Cefazolin</td>
<td>1–2 g iv 30 minutes prior to discography or cefazolin 1–10 mg/mL with intradiscal contrast</td>
</tr>
<tr>
<td>Clindamycin</td>
<td>600 mg iv 30 minutes prior to discography or clindamycin 7.5 mg/mL with intradiscal contrast</td>
</tr>
<tr>
<td>Vancomycin</td>
<td>1 g iv over 60 minutes prior to discography</td>
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iv = intravenous.

In patients with β-lactam allergy

In patients who are documented carriers of methicillin-resistant *Staphylococcus aureus*
excision. In the 18 cases where a small piece of catheter remained in the disk, there were no reports of patient morbidity. It has been estimated that 35,000 catheters had been used during that time period. Currently, there appears to be no indication that surgical removal of a sheared catheter that is left in the disk is required. Long-term observation of these patients should be undertaken to determine the long-term consequences of this occurrence. Catheter breakage can be minimized or eliminated if the operator performs the procedure carefully and avoids catheter kinking and does not make repeated attempts at forceful removal of a kinked catheter back through the introducer needle (Figure 2).

There has been one report of cauda equina injury due to IDET [25]. This case involved a patient who was sedated to a level of unresponsiveness and whose catheter position prior to heating was not checked in the lateral radiographic plane. This case resulted in an extra-discal catheter deployment in a nonresponsive patient who suffered a thermal neurologic injury. The single case of cauda equina injury following IDET that was reported [25] occurred in a patient that was oversedated and unresponsive. As the IDET catheter was advanced, the tip extended beyond the posterior margin of the annulus fibrosis and into the anterior epidural space, immediately adjacent to the thecal sac (Figure 2). The catheter’s location went unnoticed because the practitioners did not examine a lateral radiograph to determine the final position of the catheter. Treatment with a standard heating protocol commenced. Normally, as the temperature of the catheter is slowly raised, a patient who is awake would report progressively worsening discomfort in the back and extending to the lower extremities, signaling that excessive heat was reaching the nerves of the cauda equina within the thecal sac. The absolute temperature of the catheter and/or the rate at which the temperature was increased would normally be reduced in the

Figure 2 Mechanism that leads to catheter breakage and thermal injury to the cauda equina during IDET. (A) Catheter in good position for IDET treatment with the thermally active portion of the catheter (shaded) along the inner aspect of the posterior annulus fibrosis. (B) Radial tears that extend from the nucleous pulposus into the annulus fibrosis are common in patients with degenerative disk disease. The IDET catheter often extends into one or more of these radial tears during placement. Repeated attempts to forcibly advance the IDET catheter can lead to kinking of the catheter and catheter breakage. (C) Radial tears can extend from the nucleous pulposus all the way to the outer limit of the annulus fibrosis. The IDET catheter can advance through a radial tear in the annulus and out into the anterior epidural space where the catheter will lie in close proximity to the cauda equina. IDET treatment with the catheter in this position can cause direct thermal injury to the cauda equina. (Reproduced with permission from: Rathmell JP. Atlas of Image-Guided Intervention in Regional Anesthesia and Pain Medicine. Philadelphia: Lippincott Williams & Wilkins; 2006:269; Figure 27.1.)
face of such reports in the patient. However, this patient was heavily sedated and unable to report the discomfort that would have detected dangerous excessive heating before irreparable injury ensued.

There is one published report of a disk herniation following IDET [26]. Disk herniation following IDET has been observed. This may represent weakening of the annular wall due to thermal modification of collagen. It appears to be an infrequent finding, but practitioners must be aware of it and inform their patients of this possibility. All of the post-IDET disk herniations reported here were successfully treated without residual symptoms. One required disk excision and the remainder were treated with nonoperative care. Disk herniation following IDET could be due to accelerated natural history of that particular disk, secondary weakening of a disrupted annulus, or change in character of the nucleus following exposure to thermal energy. The significance of individual case reports of disk herniation must be placed in clinical perspective. Lumbar disk herniations are part of the natural history of lumbar degenerative disk disease. Large case series are needed to develop an accurate analysis of the frequency of disk herniation following IDET. Of incidental note was the occurrence of a disk herniation at a nontreated disk level in a patient in a recent randomized controlled trial examining the efficacy of IDET [27].

One case of vertebral osteonecrosis was discussed in a published report [28]. The authors of the report did not perform the IDET, discogram, or any of the spinal injections that the patient may have undergone prior to the IDET. It is unclear whether antibiotics were used for the IDET or discogram, or if the patient underwent any intradiscal injections prior to or after the IDET. The report did not present objective evidence of catheter positions during the procedure, nor was there detailed information regarding the heating protocol that was used. It has been hypothesized that placing the IDET catheter in close proximity to the vertebral endplate and conducting treatment using standard heating protocols may induce osteonecrosis.

Saal and Saal [24] carried out a survey of five centers that performed IDET. These centers were selected on the basis of their high case volumes and operator type. Each center represented a different specialty performing the IDETs. The procedures were performed in one center by orthopedic spine surgeons, in another center by an anesthesiologist/pain physician, in two centers by an interventional radiologist, and in one center by physiatrists (physical medicine and rehabilitation).

Each center was sent a detailed questionnaire asking them to list the total number of IDET cases performed during the survey period and all the complications that followed IDET procedures. In addition, they were asked to detail the outcome and follow-up care required to resolve any complications. One thousand six hundred and seventy-five consecutive IDET cases performed at the five centers between July 1997 and February 2001 were surveyed. There were six cases of transient spinal nerve injuries; five cases were believed by the operator to be due to needle placement, and one was believed to be thermally mediated. All neurologic symptoms resolved, and no persisting lesions remained. One disk space infection was noted that was treated with antibiotics. It occurred in an immunosuppressed patient who was undergoing chemotherapy for metastatic cancer. There were no cases of catheter breakage or cases of severe pain that required hospitalization. There were five cases of post-IDET disk herniation; three were noted at the IDET-treated disk level and two at adjacent levels. The composite complication rate was 10/1,675. It is interesting to note that these centers reflect a multidisciplinary spectrum of practitioners that perform IDET and includes spine surgeons, anesthesiologists, interventional radiologists, and physiatrists.

Cohen and colleagues noted eight patients out of a cohort group of 79 that had increasing symptoms following IDET [29]. One was a case of foot drop that completely resolved in 6 weeks, one was a case of burning sensation in the leg that resolved in 2 weeks, another was a case of leg paresthesias that resolved in 4 weeks, there was one case of increase in thigh pain that persisted after IDET, and one case of increased back and thigh pain in a patient who demonstrated a new disk abnormality at an adjacent untreated level.

Disk space infection (discitis) has been reported with other intradiscal techniques, particularly diagnostic discography; however, there have been no reports of discitis associated with IDET.

Prevention
It is clear that complications related to IDET do occur. Practitioners must be aware of these potential problems and appropriately inform patients that are considering IDET. The complication rates appear to be low, and most may be avoided with careful technique. Expertise in intradiscal
needle placement is required along with an accurate understanding of radiologic spinal anatomy and multiplanar fluoroscopic technique. IDET certainly has a risk profile that is far below fusion surgery [30].

The most severe complications associated with IDET stem from situations in which the catheter is placed outside the confines of the disk space. It is critical that the operator can be certain of the intradiscal location of the catheter before heating is initiated. Clearly, the knowledge of three-dimensional fluoroscopic anatomy on the part of the treating physician is essential. This requires familiarity with accurate interpretation of anteroposterior, lateral, and oblique radiographs of the lumbar spine using fluoroscopy. Symptoms must be monitored by the operator to ensure that no undue lower extremity or perineal symptoms develop. These would warrant halting the procedure and reconfirming the location of the catheter. Excessive sedation during IDET can reduce or eliminate the ability of the patient to report dangerous symptoms during treatment and must be avoided.

Theoretically, paravertebral soft tissue or disk space infection could occur following IDET despite close attention to aseptic technique. Most practitioners routinely administer intradiscal and/or intravenous antibiotics during IDET. Guidelines for prophylactic antibiotic use during IDET are similar to those for discography (Table 2).

**Nucleoplasty**

Nucleoplasty is the term given to a novel approach to percutaneous discectomy that uses a patented technology called Coblation to remove a portion of the nucleus pulposus and thereby reduce intradiscal pressure for the treatment of radicular pain due to contained disk herniations. Similar to other percutaneous discectomy techniques, the treatment probe is placed into the nucleus pulposus of an intervertebral disk through an introducer cannula. The probe is then advanced while energy is applied, and the active tip of the treatment probe creates a series of small channels within the nucleus pulposus. This treatment effectively reduces intradiscal pressure in experimental models [9].

Like other approaches to percutaneous discectomy, the concept is to reduce intradiscal pressure, thereby allowing a bulging disk or a contained disk herniation to fall away from the spinal nerve, thus relieving radicular pain. This technique is simple and there are few adverse events in the literature despite widespread application of the new technology, suggesting that the technique is safe. However, to date, there are few clinical trials available that confirm the safety or demonstrate the effectiveness of nucleoplasty.

**Complications**

Similar to other intradiscal techniques, the primary complications associated with nucleoplasty are associated with the placement of the intradiscal introducer cannula (Table 1), and this group of complications has been discussed previously in the section on discography. Although the introducer cannula used for nucleoplasty is larger in diameter than the typical 22-gauge spinal needle used to perform discography, there is no evidence to suggest that there is a higher complication rate associated with the use of this large-bore introducer. Nonetheless, it stands to reason that use of a larger needle may well lead to greater neural injury in the event of contact with a neural structure.

Early cohort studies reported favorable outcomes following nucleoplasty without any reported complications [31,32]. Bhagia et al. [33] recently detailed the side effects and complications associated with nucleoplasty. In a series of 53 patients, the most common side effects at 24 hours after treatment were soreness at the needle insertion site (76%), new numbness and tingling (26%), increased intensity of preprocedure back pain (15%), and new areas of back pain (15%). At 2 weeks after nucleoplasty, no patient had soreness at the needle insertion site or had new areas of back pain; however, new numbness and tingling were present in 15% of patients. Two patients (4%) had increased intensity of preprocedure back pain and opted for surgical discectomy.

A number of theoretical risks that have not been reported during clinical use are apparent. The technology results in marked temperature elevation and tissue destruction that is limited to the area immediately adjacent to the treatment tip of the probe [34]. If the treatment tip is withdrawn too far and the active tip is pulled back into the metal introducer, this can theoretically cause heating of the entire length of the introducer cannula. In this way, it is possible to produce thermal injury to any structure along the course of the cannula. Excessive extension of the treatment probe can lead to penetration of the anterior annulus fibrosis and extension into the retroperitoneal space, with potential damage to vascular structures in this area.
Prevention
Complications associated with placement of the intradiscal cannula during nucleoplasty are similar to prevention during any other intradiscal technique and has been described in the previous section. Prevention of complications associated with the Coblation treatment used to perform nucleoplasty relies on the disciplined use of radiographic guidance to guide insertion of the intradiscal cannula and to assure that the extent of treatment is contained within the limits of the nucleous pulposus. Thus, the extent of anterior advancement as well as retraction of the treatment probe during treatment must be guided with radiographic guidance in the lateral view. Like IDET, excess sedation during the active treatment removes a potential early warning from the patient that thermal injury to neural structures is occurring.

Conclusions
Complications associated with intradiscal techniques, including discography, IDET, and nucleoplasty, are uncommon and predominantly associated with placement of the intradiscal needle or cannula. The use of prophylactic antibiotics administered either intravenously or intradiscally during these procedures is warranted due to the deep-seated and potentially catastrophic consequences of infection within the disk space. Complications can be minimized by having a thorough familiarity with the anatomy of the intervertebral disks and adjacent neural structures, and coupling this knowledge with meticulous use of radiographic guidance in multiple planes. The use of intravenous sedation during these procedures remains controversial. While modest levels of sedation that allow the patient to communicate verbally with the operator throughout the procedure seem reasonable, the use of heavy sedation or general anesthesia that prevents any verbal communication with the patient is unwise. Particularly during the active phase of treatment, during which thermal energy is applied within the disk, an awake and conversant patient can report excessive pain, signaling potential neural injury before permanent injury has occurred. We still have much to learn about intradiscal treatments, foremost is how to effectively select patients who benefit from these minimally invasive treatments. We are certain to see rapid improvements in technology in coming years. Minimally invasive techniques are here to stay: our patients want new and effective treatments that obviate the need for open surgical intervention.

References
Complications of Discography, IDET, Percutaneous Discectomy, and Nucleoplasty