Minimally-Invasive, Interventional Spine Treatment — PART II

Diagnostic and therapeutic intradiscal interventions for pain generated from internal disc disruption.

In the last issue, we examined the common procedures and spinal injections not exclusively involving the discs and presented the most common spinal procedures utilized to diagnose and treat spinal (axial/radicular) pain. We continue our examination of the importance of minimally invasive interventional spinal treatment with a focus on pain generated from the spinal intervertebral discs.

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Diagnostic Provocation Discographic Injections

Lumbar provocation discography remains a controversial diagnostic technique; and even more so with cervical/thoracic discography. To appreciate the historical controversy surrounding discography is to understand that its inception was a tenuous one, tainted by admonitions, suppositions, and contradictions. Proponents believe discography uniquely shows internal disc anatomy and identifies clinically symptomatic (painful), or asymptomatic (non-painful) discs. In 1934, Mixter and Barr first called attention to the pathoanatomy of the herniated lumbar disc and its relationship to radicular dysfunction from neural compression. In 1952, Pierre Erlacher established the correlation of the nucleogram to nuclear anatomy by investigating cadaveric discs using contrast material and histological stains. The precise technique for lumbar discography was described in 1952 by Cloward and Busaid. Since those initial procedures were performed, improved techniques and technological advances — and a better understanding of pain — have provided much needed refinement of discography as a potentially valuable diagnostic test.

The presence of degenerative disc changes does not necessarily correlate with clinical symptoms or a painful internal disc. Provocative diagnostic testing for concordant discogenic pain is the most important aspect of discography and provides information regarding the clinical significance of concordant disc abnormalities. There is literature that suggests that the presence of outer annular fissures/ruptures (i.e., HIZ, high intensity zones) are significant predictors of a painful degenerative disc rather than the degree of disc deterioration. CT-discography has been shown to have higher sensitivity and specificity than individual CT scans, myelography, and CT-myelography for internal disc disruption (IDD, a chemically-mediated abnormality of the nucleus pulposus and annulus fibrosus with/without disc contour defects), herniated nucleus pulposus (HNP), recurrent disc herniation, and foraminal disc herniation. CT-discography interpretation is highly reproducible for grading annular degeneration and disruption (e.g., Dallas Discography Criteria). The presence of a "high intensity zone" (HIZ) on magnetic resonance imaging (MRI) has been shown to correlate 100% with an outer annular rupture by CT-discography imaging, although 54% of discs with annular ruptures did not show a HIZ on MRI. The sensitivity and specificity of an HIZ in identifying those discs that exactly reproduce discographic pain was 82% and 89%, respectively. Although MRI with gadolinium may be more accurate than CT-discography in distinguishing recurrent disc herniations from postoperative scar tissue, CT-discography is more sensitive than myelography, CT scans, or CT-myelography for determining intradiscal morphology. At the present time, MRI does not appear to be as sensitive or specific as CT-discography in determining whether or not a disc is symptomatic. Discography and CT-discography have found abnormalities despite normal MRI scans and, conversely, found asymptomatic discs in the presence of significantly abnormal MRI studies. Although MRI can reliably detect disc degeneration and, in certain cases, predict painful annular ruptures, many believe that only provocative discography can consistently determine the presence or absence of symptomatic annular ruptures/fissures.

Lumbar discography uniquely tests for concordant pain reproduction in addition to investigating the internal disc structural integrity. In cases of IDD and indeterminate nuclear changes on MRI, discography can be beneficial. The major indications for lumbar discography include:

- Surgical planning for a lumbar fusion/artificial disc replacement/percutaneous disc decompression.
- Identifying the presence or absence of a painful disc among multiple degenerative discs;
- Testing the structural integrity of an adjacent disc to a known abnormality such as spondylolisthesis or fusion;
- Evaluating a suspected lateral/foraminal or recurrent disc herniation.

In addition, discography is an integral part of intradiscal therapeutic procedures (e.g., intradiscal electrothermal annuloplasty/decompression, annular denervation, percutaneous radiofrequency/laser microdiscectomy). According to the 1988 Position

Statement on Discography by the Executive Committee of the North American Spine Society: "Discography is indicated in the evaluation of patients with unremitting spinal pain, with or without extremity pain, of greater than 4 month's duration, when the pain has been unresponsive to all appropriate methods of conservative therapy…" Although controversial, the concept of discogenic pain is described as a centralized/axial, nonradicular pain produced during certain provocative manuevers. Patients can also have diffuse, nondermatomal lower limb pain that is associated with the lower back pain but not typically in isolation. Lumbar discography is believed to identify the presence or absence of symptomatic discs in patients with chronic axial low back pain. Therefore, proponents argue that the value of discography lies in its ability to provocatively test the discs for reproduction of discogenic back and, occasionally, leg pain.

In appropriately trained hands, the risk of complications from lumbar discography is very minimal. Potential complications from discography include discitis, nerve root injury, subarachnoid puncture, chemical meningitis, bleeding, and allergic reactions. These adverse events can be minimized by pre-treating individuals for contrast dye allergies, using non-ionic contrast dye, and using meticulous sterile techniques.Prophylactic antibiotics (intravenous, intradiscal, and oral) may substantially further decrease the risk of infections.[1-33]

Therapeutic Intradiscal Procedures

The application of lumbar discography in diagnosing internal disc disruption (IDD) has provided the interventional spinal specialist with information in order to consider various non-surgical and surgical treatment options. The following sections briefly discuss some of the methods of minimally-invasive therapeutic intradiscal procedures which are being used for internal disc disruption and contained disc herniations:

- IntraDiscal ElectroThermal (IDET/EDD) Annuloplasty/Decompression,
- Percutaneous Mechanical Disc Decompression (DeKompressor)
- Percutaneous Laser Disc Decompression (PLDD-LASE), and
- Percutaneous Radiofrequency (RF) Intradiscal (Nucleoplasty)/Annular (DiscTrode) Neurolysis.

IntraDiscal ElectroThermal (IDET/EDD) Annuloplasty

IDET/EDD annuloplasty (using the SpineCATH Intradiscal Catheter; Smith-Nephew,Inc.) is a novel addition to the interventional physician's armamentarium of treatments for patients with painful degenerative disc disease and IDD. IDET/EDD provides a new outpatient treatment option for patients who would not be recommended for—or who do not elect—other more invasive treatments such as lumbar disc surgery (i.e., open discectomy or surgical fusion). The SpineCATH intradiscal catheter has been approved by the Federal Drug Administration (FDA) for use in treating symptomatic patients with annular disruption of contained lumbar herniated discs. This new technology has been developed to safely treat intervertebral discs in a minimally-invasive manner and still provide physicians with a definitive approach to addressing internal disc disruption. The intradiscal catheter delivers controlled thermal energy directly to the annular wall and disc nucleus via a resistive heating coil; which then aims to create temperature-controlled coagulation and shrinkage of intradiscal collagenous tissue. The SpineCATH system was developed to thermo-coagulate annular tissue/nociceptors, thermally modulate intradiscal collagen tissue, cauterize granulation tissue, as well as reduce nuclear volume in small, contained disc herniations. The steerable catheter design allows for precise intradiscal navigation for percutaneous spinal intervention. Usually performed under light conscious sedation, the catheter is inserted through a 17-gauge introducer trochar needle and is easily positioned with fluoroscopic guidance. Since this procedure is significantly less invasive than other disc surgeries; the result is a percutaneous, outpatient procedure that is no more invasive than a lumbar discogram. The initial success rate for the procedure, variably depending on patient selection, has been noted to be around 60-75%.

The disc itself is a virtually avascular structure which allows heat to be held in the tissue with relatively little fluctuation during treatment. Adjacent structures are protected from thermal injury by the vascular circulation outside the disc which quickly dissipates any heat conducted beyond the disc. Temperature and power control give the IDET/EDD catheter the optimal ability to deliver focused energy at the point of contact. Heat is transferred by conduction from the catheter to the adjacent disc tissue. Temperature sensors deliver feedback to the generator which adjusts power levels as necessary to reach and maintain set target catheter temperatures. Optimum treatment temperatures are followed as previously documented in temperature mapping experiments done in the cadaveric and in-vivo validation studies. These mapping studies indicated that optimal temperature levels (80–90 deg C) are reached for achieving collagen modulation and for nociceptor destruction in the outer annular wall (47-49 deg C) — while maintaining low epidural temperature levels (maximum 40.6 deg C) to avoid damaging myelinated nerves. The generator controls the SpineCATH catheter temperature accurately and precisely to maintain the optimum treatment temperature. These validation studies also documented an average total disc volume reduction of 12.7% (range: 10-16.7%) due to morphologic changes in the outer disc surface. It was estimated that in the area of treated tissue alone (tissue reaching at least 60 degrees C) there was an approximate 40% decrease in disc tissue volume.

The indications noted for the IDET/EDD annuloplasty procedure include axial back pain and mild referred leg pain due to symptomatic (painful) internally disrupted disc with annular fissures (documented through discography) and symptomatic (painful) contained-disc herniation without significant radicular symptoms. Other potential IDET/EDD candidates include:

- Patients with discogenic pain after a previous discectomy;
- Disc space volume >50%;
- Some multi-level degenerative disc disease involvement;
- Discogenic pain above or below a previous fusion.

The procedure is contraindicated in patients with the following:

- Severe radicular symptoms due to frankly herniated discs or sequestered/extruded discs on MRI;
- Compressive pathology due to significant spinal stenosis;
- Segmental instability/listhesis;
- Severely collapsed discs (<50% disc volume).

The complications are similar to those noted in the discography section previously stated.

Percutaneous Mechanical Disc Decompression (DeKompressor)

Percutaneous lumbar discectomy (PLD) procedures have been around for over three decades, in one form or another, using different technologies for relief of axial lower back and radicular pain; and with success rates of over 90%, for open surgical discectomy over the last 50 years. Benefits resulting from the use of PLD techniques have been reported to include: good-excellent success rates, reduced procedural trauma, lower outpatient treatment costs, rapid post-surgical rehabilitation progress, and lower morbidity rates. Less invasive methods for percutaneous discectomy and intradiscal disc decompression will play an important role in the future treatment of patients suffering from the effects of disc herniations/compressions. The "DeKompressor" (from Stryker, Inc.) involves a 1.5mm diameter percutaneous lumbar discectomy probe to perform mechanical disc decompressions using a highly efficient, minimally-invasive mechanical method for aspiration and removal of intervertebral disc nucleus pulposus — via creating a channel and intradiscal evacuation entirely under fluoroscopic guidance. The patented probe tip utilizes an Archimede's extraction pump principle to mechanically remove nucleus pulposus from the affected disc herniation or contained disc bulge. This results in intradiscal pressure reduction and subsequent decompression of the surrounding affected nerve root with resulting radicular/axial pain relief. Further controlled, randomized clinical research studies are needed to validate this technique although, under good selection criteria guidelines, the initial results seem promising.

Percutaneous Laser Disc Decompression (PLDD)

The PLDD procedure has been around for over two decades in one form or another using different laser types, technology, and methodology. The LASE method (Clarus Medical Systems, Inc., Minneapolis, MN) of PLDD is relatively new (within 15 years) with an endoscopically, visualized fiberoptic scope and utilizing the Holmium YAG laser. The technique is designed to reduce the bulging nucleus enough to eliminate the pressure it is placing on the surrounding nerve. A miniature endoscope with a laser fiber is inserted into the disc, leaving an incision through the skin which is less than 0.25 inch. The LASE endoscope allows the physician to view the bulging nucleus tissue and remove it with the laser fiber using high temperature thermocoagulation/extraction. By removing/thermocoagulating the affected nuclear disc tissue with concurrent suction/lavage of extracted tissue, the pressure on the injured nerve root is reduced or eliminated along with the resultant pain. Over 50,000 LASE procedures have been performed since inception. Multiple studies have shown that around 80% of properly selected patients with contained herniated discs having lower back and leg pain, may benefit from this procedure. The essence of the procedure is that it performs an outpatient discectomy without the risks of routine open invasive surgery. The procedural recovery time is approximately 2-4 weeks. Although not a panacea, the procedure is less indicated in primarily axial back pain of discogenic etiology, lumbar stenosis due to degenerative conditions, or failed back surgery syndrome with perineural scar tissue. The complications and risks are similar to those noted for the IDET and lumbar discography procedures.

Percutaneous Radiofrequency (RF) Intradiscal/Annular Neurolysis

Percutaneous Radiofrequency (RF) Annular Neurolysis or Denervation was developed primarily by M.E. Sluijter in the 1980's. Dr. Sluijter proposed a method to denervate the intervertebral disc through thermocoagulation and reported a series of patients who had obtained relief of their chronic low back pain with annular denervation. It was proposed as a treatment for internal disc disruption (IDD) and painful disc degeneration (PDD). Annular denervation uses the same technology used in percutaneous radiofrequency (RF) neurolysis utilized to treat spasticity, malignant pain, trigeminal neuralgia, and zygapophyseal joint medial branch nerve pain. Dr. Sluijter theorized that intradiscal placement of a RF probe would globally increase disc temperature and produce neurolysis of the nociceptive fibers found in the outer annulus. Critics argued that the lesion generated by the RF probe (which technically only covers a 6mm radius from the probe tip) would not reach the annular fibers but previous studies have noted elliptical or spheroid denervation areas secondary to induced tissue temperature elevation and not from any direct heating effects of the probe itself. Therefore the area of coagulation is dependent on temperature, probe size, and probe orientation. Similar to the IDET and PLDD procedures, the RF annular denervation procedure needs further clinical studies and consistent clinical results but seems safe for the treatment of IDD and PDD refractory to conservative care (e.g., Radionics DiscTrode Annuloplasy). The indications, risks, and complications are similar to the IDET, PLDD, and lumbar discography procedures. The risk of infection, hemorrhage, and neurologic insult is considered to be significantly reduced when compared with any open surgical disc procedure.[34-55]

Percutaneous intranuclear radiofrequency discectomy (e.g., Arthrocare Disc Nucleoplasy), a minimally-invasive intradiscal procedure utilizing a patented "Coablation" technology for the ablation and coagulation of intradiscal soft tissue, combines elements of previous approaches for partial decompression of nucleus pulposus. The procedure builds upon the benefits of these previous approaches by providing a more controlled, efficient, and practical method of nuclear tissue extraction, while retaining the underlying minimally-invasive rationale. Originally devised by ArthroCare Corp. in Sunnyvale, California, disc nucleoplasy utilizes a multifunctional bipolar radiofrequency device which generates a "cold-energy" plasma-enhanced process, in which radiofrequency energy is applied to a conductive medium (saline) to generate a precisely-focused, low-temperature ionic plasma field around the electrode at the tip of Perc-DLE/DLR SpineWand ("Coablation"). The plasma of highly-ionized particles have enough energy to break the molecular bonds within tissue at low temperatures (~40-70 deg C). A series of 6-9 channels are created in the disc nucleus by radiofrequency ablation and coagulating tissue. Approximately 1-2 cc of nuclear tissue, or roughly 10-15% of nucleus pulposus is thus thermally removed. This highly-focused, controlled thermal coablation technique allows an effective percutaneous disc decompression with minimal risk of thermal injury to surrounding tissue. The procedure is performed in an outpatient setting with fluoroscopic guidance and conscious sedation. Initial clinical study results up to one to two years following the procedure have

shown that VAS pain scores, as well as narcotic use are substantially reduced; with patient satisfaction as high as 89%. However, further prospective, controlled, randomized studies should be undertaken to demonstrate the benefits, limitations, and clinical outcomes of this novel procedure.

Conclusions

Part II of this two part series has examined the diagnostic and therapeutic intradiscal, minimally-invasive interventions available for treatment of pain originating from spinal vertebral discs. The objective of these minimally-invasive interventional techniques is to diagnose and stabilize spinal-based pathologies that generate pain so that the patient can engage in comprehensive rehabilitation and subsequent improvements in quality of life with reduction in overall pain conditions. The combination of these therapeutic intradiscal procedures—together with neuromuscular rehabilitation—continues to demonstrate exceptional results.■

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References

1. Gibson MJ et al. Magnetic resonance imaging and discography in the diagnosis of disc degeneration. A comparative study of 50 discs. *J Bone Joint Surg*. 1986. 68: 369-373.

2. Holt EP. The question of lumbar discography. *J Bone Joint Surg.* 1968. 50: 720-726.

3. Horton WC and Daftari TK. Which disc as visualized by magnetic resonance imaging is actually a source of pain? A correlation between magnetic resonance imaging and discography. *Spine*. 1992. 17: S164-S171.

4. Schneiderman G et al. MRI in the diagnosis of disc degeneration: Correlation with discography. *Spine*. 1987. 12: 276-281.

5. Scullin DR. Lumbar discography. *Radiology*. 1987. 162: 284-286.

6. Simmons JW. et al. A reassessment of Holt's data on: "The question of lumbar discography." *Clin Orthop Rel Res*. 1988. 237: 120-124.

7. Vanharanta H et al. The relationship of pain provocation to lumbar disc deterioration as seen by CT/discography. *Spine*. 1987. 12: 295-298.

8. Zucherman J et al. Normal magnetic resonance imaging with abnormal discography. *Spine*. 1988. 13: 1355-1359.

9. Colhoun E et al. Provocation discography as a guide to planning operations on the spine. *J Bone Joint Surg.* 1988. 70: 267-271.

10. North American Spine Society: Position statement on discography. The Executive Committee of the North American Spine Society. *Spine*. 1988. 13: 1343.

11. Simmons EH and Segil CM. An evaluation of discography in the localization of symptomatic levels in discogenic disease of the spine. *Clin Orthop Rel Res.* 1975. 108: 57-69.

12. Erlacher PR. Nucleography. *J Bone Joint Surg*. 1952. 34: 204-210.

13. Cloward RB and Busaid LL. Discography. Technique, indications, and evaluation of normal and abnormal intervertebral discs. *AJR Am J Roentgenol*. 1952. 68: 552-564.

14. Maezawa S and Muro T. Pain provocation at lumbar discography as analyzed by computed tomography / discography. *Spine*. 1992. 17: 1309-1315.

15. Moneta GB et al. Reported pain during lumbar discography as a function of annular ruptures and disc degeneration. *Spine*. 1994. 19: 1968-1974.

16. Antti-Poika I et al. Clinical relevance of discography combined with CT scanning. A study of 100 patients. *J Bone Joint Surg*. 1990. 72: 480-485.

17. Bernard TN. Lumbar discography followed by computed tomography. Refining the diagnosis of low back pain. *Spine*. 1990. 15: 690-707.

18. McCutcheon ME and Thompson WC. CT scanning of lumbar discography. A useful diagnostic adjunct. *Spine*. 1986. 11: 257-259.

19. Milette PC et al. Comparison of high-resolution computed tomography with discography in the evaluation of lumbar disc herniations. *Spine*. 1990. 15: 525-533.

20. Aprill C and Bogduk N. High-intensity zone: A diagnostic sign of painful lumbar disc on magnetic resonance imaging. *Br J Radiol*. 1992. 65: 361-369.

21. Collins HR. An evaluation of cervical and lumbar discography. *Clin Orthop*. 1975. 107: 133-138.

22. Collis JS and Gardner WJ. Lumbar discography: Analysis of 600 degenerated discs and diagnosis of degenerative disc disease. *JAMA*. 1961. 178: 167-170.

23. Brodsky AE and Binder WF. Lumbar discography: Its value in diagnosis and treatment of lumbar disc lesions. *Spine*. 1979. 4: 110-120.

24. Patton JT. Discography in assessment of lumbar disc disease. Ann Rheum Dis. 1975. 34: 466-467.

25. Preacher WG and Storrs RP. The roentgen diagnosis of herniated disc with particular reference to discography (Nucleography). *AJR Am J Roentgenol*. 1956. 76: 290-302.

26. Simmons EH. Discography: Localization of symptomatic levels. *J Bone Joint Surg*. 1975. 57: 261.

27. Crock HV. A reappraisal of intervertebral disc lesions. *Med J Aust*. 1970. 1: 983-989.

28. Walsh TR. et al. Lumbar discography in normal subjects. *J Bone Joint Surg*. 1990. 72: 1081-1088.

29. Fraser RD. et al. Iatrogenic discitis: The role of intravenous antibiotics in prevention and treatment. *Spine*. 1989. 14: 1025-1032.

30. Osti OL, et al. Discitis after discography. The role of prophylactic antibiotics. *J Bone Joint Surg*. 1990. 72: 271-274.

31. Konings J and Veldhuizen AG. Topographic anatomical aspects of lumbar disc puncture. *Spine*. 1988. 13: 958-961.

32. Guyer RD et al. Discitis after discography. *Spine*. 1988. 13: 1352-1354.

33. Gardner WJ et al: X-ray visualization of the intervertebral disc: With a consideration of the morbidity of disk puncture. *Arch Surg*. 1952. 64: 355-364.

34. Taken with permission from IntraDiscal ElectroThermal Therapy (IDET/EDD), Training Course Syllabus; Oratec Interventions, Inc., Menlo Park, CA.; Training Seminar in Memphis, TN. April 05, 1999.

35. Taken with permission from Clarus LASE Percutaneous Laser Disc Decompression System (PLDD), Training Course Syllabus and Research Literature/ Bibliography (unpublished data). Clarus Medical Systems, Inc. Minneapolis, MN. Training Course in Marietta, GA. June 20, 1999.

36. Sluijter ME. The use of radiofrequency lesions for pain relief in failed back patients. *Int Disabil Stud*. 1988. 10: 37-43.

37. Troussier B et al. Percutaneous intradiscal radiofrequency thermocoagulation. A cadaveric study. *Spine*. 1995. 20: 1713-1718.

38. Windsor RE. Radiofrequency annular lesioning in chronic low back pain. Presented at the International Spinal Injection Society Annual Meeting. April 1994.

39. Windsor RE and Gore HC. Annular denervation in chronic low back pain. *Phys Med & Rehab: State of the Art Reviews*. 1999. 13(3): 625-630.

40. Sluijter ME and Van Kleef M. The RF lesion of the lumbar intervertebral disc. *Maastricht*. 1994. 13: 424-428.

41. Sluijter ME. Letter to the editor. *Spine*. 1998. 23: 745.

42. Windsor RE, Falco FJ, and Furman MB. Therapeutic Lumbar Disc Procedures. In Weinstein SM (Ed.): *Phys Med & Rehab Clinics of North America: Injection Techniques*. W.B. Saunders. Philadelphia, PA. Nov. 1995. pp 771-783,

43. Graham CE. Percutaneous posterolateral lumbar discectomy. An alternative to laminectomy in the treatment of backache and sciatica. *Clin Orthop*. 1989. 238: 104-106.

44. Ray CD. Percutaneous discectomy. A new day-surgical method for herniated lumbar discs. *Minn Med*. 1988. 71: 485-488.

45. Bogduk N et al. Technical limitations to the efficacy of radiofrequency neurotomy for spinal pain. *Neurosurgery*. 1987. 20: 529-534.

46. Langberg JJ et al. Radiofrequency catheter ablation: The effect of electrode size on lesion volume in vivo. *PACE*. 1990. 13: 1242-1248.

47. Moringlane JR et al. Experimental radiofrequency (RF) coagulation with computer-based on-line monitoring of temperature and power. *Acta Neurochirurgica*. 1989. 96: 126-131.

48. Derby R. *Intradiscal electrothermal annuloplasty*. Presented at the 13th Annual Meeting of the North American Spine Society. San Francisco, CA. October 1998.

49. Saal J and Saal J. *A novel approach to painful disc derangement: Collagen modulation with a thermal percutaneous navigable intradiscal catheter: A prospective trial*. Presented at the 13th Annual Meeting of the North American Spine Society. San Francisco, CA. October 1998.

50. Saal J, Saal J, and Ashley J. *Thermal characteristics and the lumbar disc: Evaluation of a novel approach to targeted intradiscal thermal therapy*. Presented at the 13th Annual Meeting of the North American Spine Society. San Francisco, CA. October 1998.

51. Derby R et al. *Intradiscal Electrothermal Therapy by Catheter: 12-month Follow-up*. Presented at the 7th Annual Scientific Meeting of the International Spinal Injection Society. Daly City, CA. August 1999.

52. Lee J, Lutz GE, et al. *Stability of the Spine after Intradiscal Electrothermal Therapy*. Presented at the 7th Annual Scientific Meeting of the International Spinal Injection Society. Daly City, CA. August 1999.

53. Karasek, M, Karasek, D, and Bogduk N. *A controlled trial of the efficacy of intra-discal electrothermal treatment for internal disc disruption*. Presented at the 7th Annual Scientific Meeting of the International Spinal Injection Society. Daly City, CA. August 1999. & 14th Annual Meeting of the North American Spine Society. Chicago, IL. October 1999.

54. Saal J and Saal J. *Intradiscal Electrothermal annuloplasty (IDET) treatment for chronic multi-level discogenic pain: Prospective 1 year follow-up outcome study*. Presented at the 14th Annual Meeting of the North American Spine Society. Chicago, IL. October 1999.

55. Maurer P. *Thermal lumbar disc annuloplasty: Initial clinical results*. Presented at the 14th Annual Meeting of the North American Spine Society. Chicago, IL. October 1999.

56. Pinzon EG. Minimally-Invasive Spine Interventions. *Practical Pain Management*. Jan/Feb, 2003. Vol. 3(1): 20-24.

57. Pinzon EG. Treating Lumbar Back Pain. *Practical Pain Management*. Mar/Apr, 2001. 1(1): 14-20.