Microtherapy in Low Back Pain

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30.1 Terminology

Experimental in vivo stimulation of the annulus fibrosus of an intervertebral disc produced back pain, and the term "discogenic pain" was coined [1] to establish the association between annulus stimulation and the subjective pain perception. Histologically the end organ neural sensors are located in the outer layers of the annulus, epiannular surface, and the juxta endplate region [2–4]. Nucleus pulposus and its metabolic byproducts are known contact irritants to the nerve tissues and are known to reduce their membrane excitation threshold [5–10]. There is no direct contact between the neural end sensors and the intradiscal irritants in an intact disc.

Annular defects are demonstrated in degenerative discs in postmortem studies [11] and in in vivo discographic examinations [12–15] (Fig. 30.1). It is hypothesized that the degenerative process, trauma, and possibly metabolic changes lead to fissuring of the annulus fibrosus and defects in the endplates which bring the neural end sensors into chronic contact with the intradiscal irritants. Under these conditions, irritants have unimpeded entry into the sensory fields through annular fissures/tears/clefts. Defects in the annulus create an inflammatory response and ingrowth of granulation tissue [14], new vessels, and new nerve endings (Figs. 30.2, 30.3). Chronic exposure of the neural end sensors to the irritant in the annular defects is hypothesized to be the local pain sensitization pathway that leads to chronic lumbar discogenic pain (CLDP).

Chronic lumbar discogenic pain is a difficult condition to treat, as its pathogenesis is multifactorial and

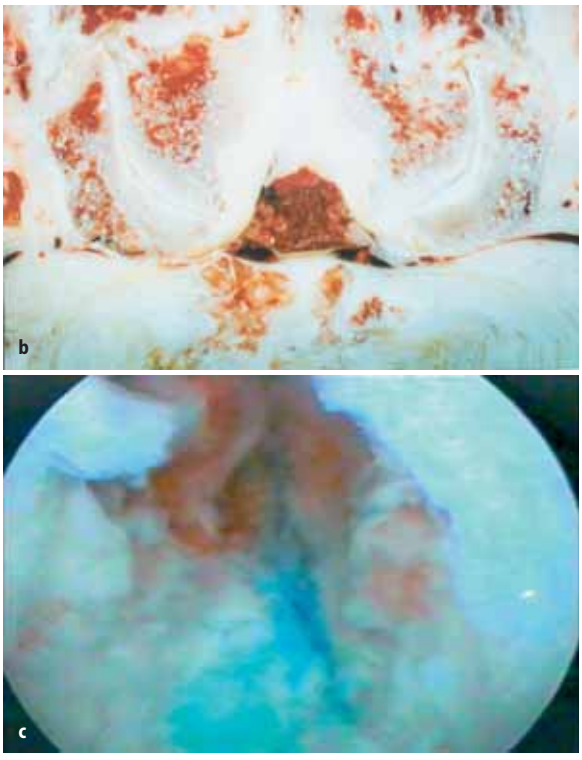

Fig. 30.1. a Lateral MRI of a patient with chronic lumbar discogenic pain (CLDP). MRI demonstrates large L4-5 high intensity zone (HIZ) representing an annular tear associated with a small disc protrusion. **b** A cadaveric axial section at L4-5 showing clumps of reddish tissue representing inflammatory granulation tissue. This tissue is the pathoanatomy represented by the HIZ seen on MRI. This granulation tissue fills annular ruptures and carries blood vessels and nociceptive pain fibers. Courtesy of W. Rauschning. **c** Endoscopic view of annular tear after Selective Endoscopic Discectomy (SED). Endoscopic view of the annular tear. The degenerative nucleus pulposus has been removed, revealing the annular tear and granulation tissue adjacent to the tear

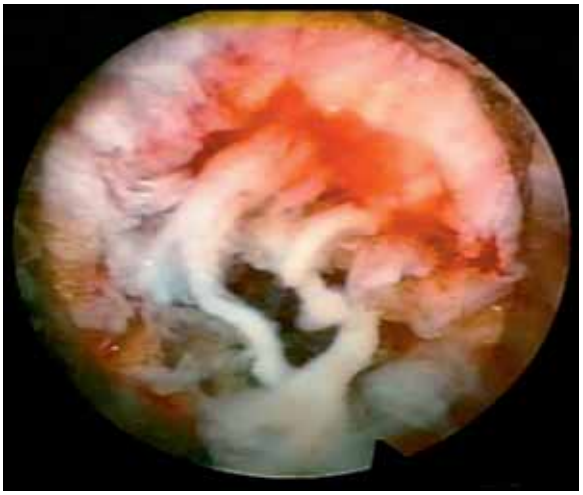

Fig. 30.2. Neoneurogenesis. Minute nerve filaments of non-myelinated nerves are sometimes visualized when there is a thick inflammatory membrane

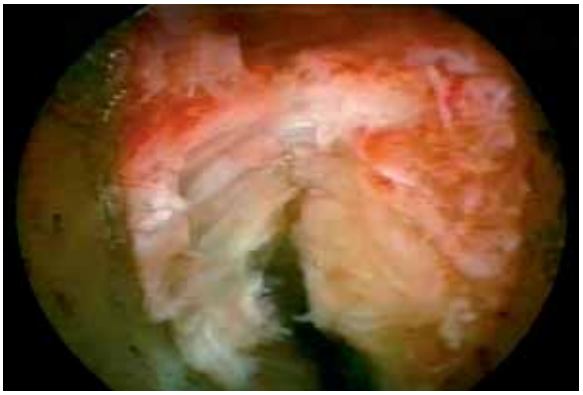

Fig. 30.3. Radial annular tear to the outer annular fibers. Inflammatory granulation tissue is seen in and around annular fissures

only partially understood. Non-operative therapeutic regimens often fail to achieve sufficient pain relief. Injection therapies with epidural steroids are good at relieving radiculitis, but are less successful at helping low back pain. Surgical options vary greatly, ranging from minimally invasive treatments such as intradiscal electrothermal therapy to 360° fusion.

Despite initial studies that seem promising for IDET, long-term results are lacking and patient selection is critical. The morbidity associated with the fusion technique, while better accepted and more thoroughly studied, is significant when considering only 65–80% of patients obtain satisfactory clinical results [16–20] and the morbidity of the procedure often creates more problems when the procedure fails. Posterolateral Selective Endoscopic Discectomy (SED) and radiofrequency (RF) thermal annuloplasty is a minimally invasive treatment option for CLDP. This procedure, developed by the senior author, was investigated in 1997 and approved by the IRB at St. Luke's Medical Center, Phoenix, Arizona [21, 22].

30.2 Surgical Principle

The senior author's early experience with laser disc decompression (LDD) and early studies on his use of the KTP laser and RF as an adjunct in arthroscopic removal of contained disc herniations concluded that 65% of the surgical patients also obtained relief of their back pain [23, 24]. Kambin's arthroscopic microdiscectomy instruments and technique allowed for visualization of the disc and annulus. This influenced the evolution of SED to include thermal modulation of disc, the inflammatory membrane, and granulation tissue surrounding the annular defect in disc herniations. Targeted thermal energy on these annular defects has demonstrated shrinkage of annular defects and ablation of inflammatory tissue in the disc. Yeung coined and trademarked the terms Selective Endoscopic Discectomy and Intraoperative Evocative Chromo-discography, using indigo carmine dye mixed with the non-ionic radio-opaque radiographic agent Isovue 300 in every endoscopic discectomy procedure. The dye has an affinity for the acidic degenerative nucleus pulposus, and helped target the disc tissue to be removed. The procedure was approved by an IRB protocol investigating the use of a flexible temperature-controlled probe in the course of endoscopic foraminal surgery for the full spectrum of discogenic pain and disc herniations.

The treatment rationale for SED and RF thermal annuloplasty is similar to the rationale for intradiscal electrothermal therapy (IDET). IDET utilizes electrothermal energy delivered to the annulus through a thermal resistive wire heated to 90° C for about 15 minutes. The electrothermal energy theoretically ablates the sensitized nerve endings in the outer annulus and annular tears making them less painful. It is also theorized to shrink the collagen fibers and thus help seal the annular tears. IDET is limited, however, because it is a fluoroscopically guided, but "blind" procedure. Ideal wire placement is at the nucleus/annulus junction or within the annular wall, but cannot be completely verified based on fluoroscopy. There is also uncertainty if the heat will actually reach the targeted fissures and associated nerve endings in each clinical case. Additionally, the physician cannot see when or if the electrothermal energy is achieving the desired tissue modulation to shrink the tear. The arbitrary length of annular heating may be inadequate to achieve the desired tissue effect or worse, may be too long, creating tissue destruction, necrotic degeneration, and pain sensitization.

Selective Endoscopic Discectomy and RF thermal annuloplasty is a fully visualized and targeted applica-

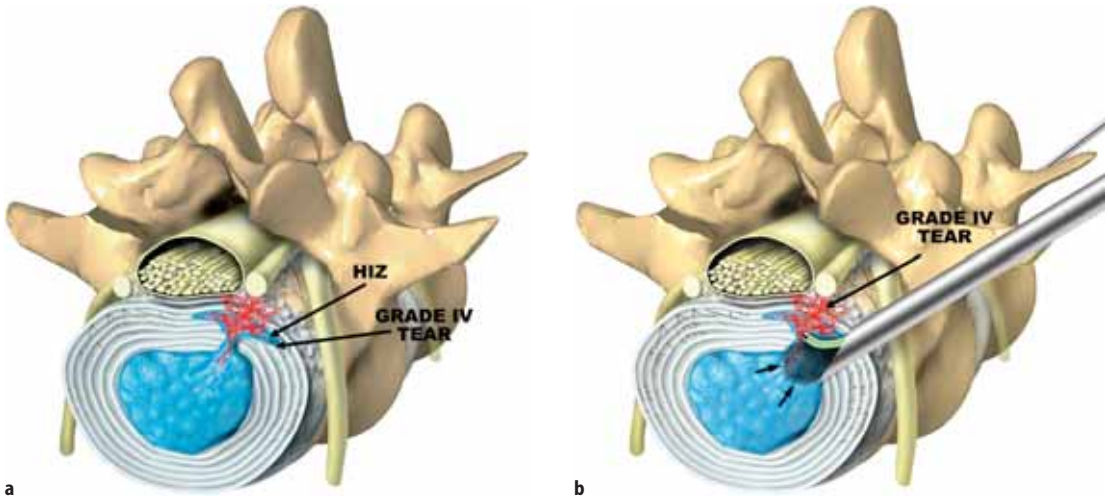

Fig. 30.4. a Illustration of a typical one quadrant grade IV annular tear. Chromo-discography stains the nucleus pulposus and the tract of the radial tear light blue. If there is communication with the blood supply in the outer annulus, an inflammatory response develops, but if the tear does not reach the vascular portion of the annulus, the annular collagen may just be torn, but there is no inflammation. **b** Illustration of SED and radiofrequency (RF) thermal annuloplasty. The *black arrows* denote the working cavity created by the selective discectomy. The flexible RF probe is shown ablating the granulation tissue within the annular tear. The position of the cannula and instruments in the posterolateral approach is optimally 25 – 35° in the coronal plane to allow access to the posterior portion of the disc

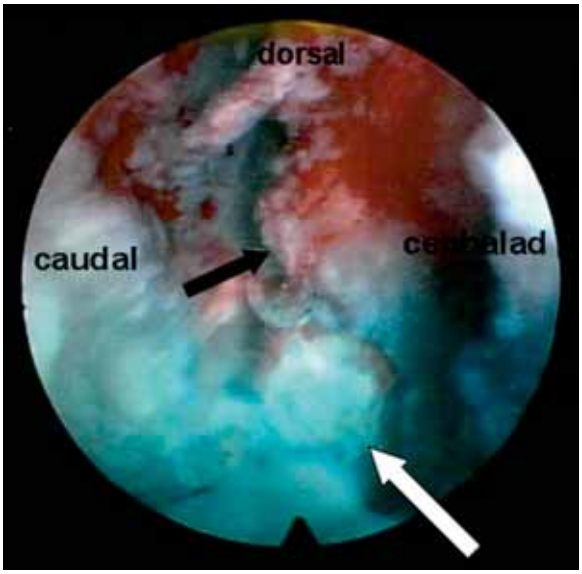

Fig. 30.5. Large posterior annular defect viewed through the 70° endoscope. The edges of the defect have inflamed granulation tissue (*black arrow*). There is also blue-stained degenerated nucleus pulposus within the defect (*white arrow*). This interposed nuclear tissue can prevent the tear from healing. All of this will be targeted with the bipolar RF probe

tion of electrothermal energy [25, 26] (Fig. 30.4). An endoscope is placed into the disc through the posterolateral transforaminal portal. Under direct visualization, the degenerative nucleus pulposus is removed and the disc cavity subsequently inspected. Disc tissue and granulation tissue is often identified in the layers of the annulus. The disc and granulation tissue is removed and ablated with a combination of mechanical instruments, Ho:YAG side-firing laser, and a bipolar flexible RF probe [26]. This not only removes the painful irritant, but also creates an environment to allow the tear to heal as the edges can now reapproximate and the intradiscal pressure is reduced (Fig. 30.5). The annular defects are endoscopically observed to contract and shrink after RF treatment. The granulation tissue and associated inflammatory membrane often seen in sensitized discs is completely ablated. This visual confirmation guides the extent of treatment. The RF electrode heating process is also hypothesized to ablate the sensitized neural sensory endings that have grown into the fissures [27, 28]. The continuous saline irrigation during the endoscopic procedure flushes out the toxic metabolites within the disc. It also prevents the accumulation of any by-products of the thermal treatment which can be neural irritants. Only scant carbonization of the tissues is observed.

30.3 History

Kambin, Hijikata, Mayer, De Antoni, Pimenta, and Leu are leaders in minimally invasive endoscopic spine procedures in their respective continents. In spite of their efforts and their experience with minimally invasive spine surgery, the techniques have been slow to gain acceptance because of the high learning curve and, in some cases, the lack of good visualization when compared with minimally invasive approaches using the

microscope. When the endoscope gained more acceptance, the approach most accepted has still been the traditional transcanal approach utilizing smaller incisions and tubular retractors. The decade of the late 1990s, however, brought increasing acceptance of endoscopic techniques and the foraminal and far lateral retroperitoneal approach as an alternative approach that spares the important dorsal muscle column implicated in Failed Back Surgery Syndrome.

Lumbar posterolateral intradiscal nuclectomy for the purpose of indirect nerve root decompression was first independently attempted by Hijikata [29] and Kambin [30] in 1973. Forst and Hausmann [31] used an arthroscope to view the intradiscal space in 1983.

In 1989 Schreiber [32] injected indigo carmine, a blue color vital dye, for intradiscal differential staining. Indigo carmine (10–20%) selectively stains the more acidic and fragmented degenerated nucleus pulposus, as demonstrated by direct visualization. The staining helps the surgeon locate and selectively remove or ablate this blue-stained degenerative tissue interposed within annular fissures. Although acute lumbar disc herniation has reliable correlating clinical symptomatology and imaging studies, CLDP has no generally agreed upon criteria in either area.

In two separate prospective randomized studies, Mayer [33] and Hermantin [34] showed equal or better satisfaction with posterolateral endoscopic discectomy versus posterior transcanal discectomy in treating herniated nucleus pulposus (HNP), non-extruded and sequestered lumbar disc herniations amenable for percutaneous decompression.

Yeung described SED for extruded herniated nucleus pulposus [25, 35] and consistently documented a decrease in low back pain (LBP) in addition to the resolution of sciatica. After achieving clinical success in relieving LBP, Yeung began treating discogenic LBP with RF thermal annuloplasty with encouraging results [21].

Abnormal patterns of intradiscal radiologic contrast images were first reported by Lindblom [36] in 1941 in a postmortem injection study. Patterns of abnormalities in discographic images have been classified [15, 37, 38]. Hirsch [39] introduced the concept of provocation saline disc injection to identify painful/symptomatic discs when patients experienced a subjective painful response to disc pressurization. Other investigators have studied provocation discography [11, 40–44], with mixed conclusions regarding the reliability of this test for clinical use. Due to the conflicting literature, provocative discography remains controversial, but is the only practical provocative test to identify a painful disc (discogenic pain). It is commonly used to confirm that a disc is a pain generator, and thus a suitable target for treatment by fusion, disc arthroplasty, or other minimally invasive intradiscal procedures including SED and RF thermal annuloplasty [13] (Fig. 30.6).

30.4 Advantages

The advantages of SED and RF thermal annuloplasty lie in the minimally invasive nature of the treatment compared to fusion. The surgical approach relies on tissue dilation rather than cutting. The posterolateral transforaminal approach spares the important dorsal muscle column. It is a motion-sparing treatment that retains

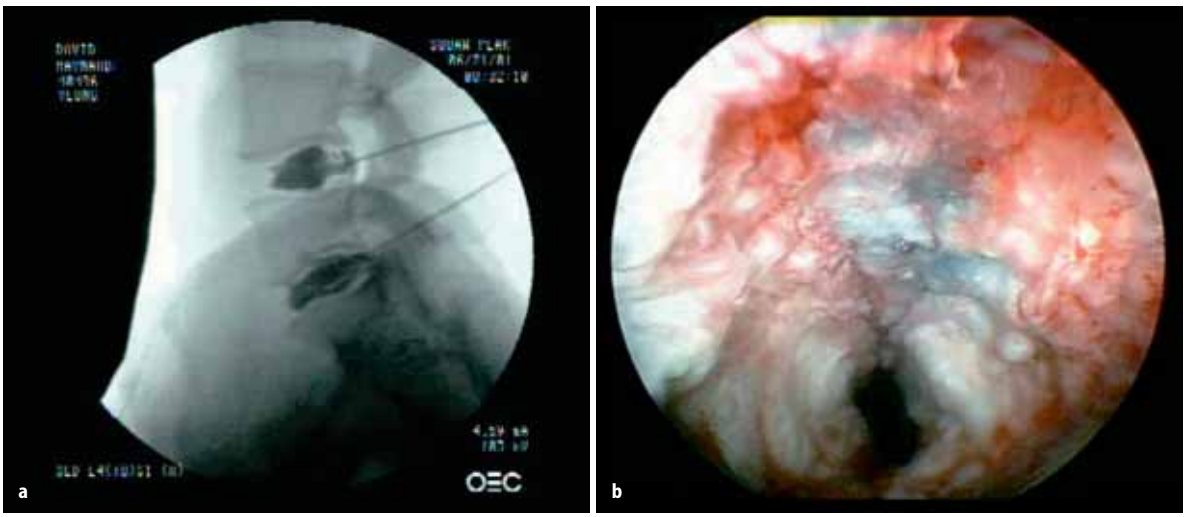

Fig. 30.6. a Lateral discogram at L4-5 and L5-S1. The discogram at L4-5 outlines a symptomatic grade IV radial tear. At L5-S1, a degenerative pattern is identified, but the disc is asymptomatic. **b** Endoscopic view of L4-5 radial tear. The annulus is still mostly intact, but inflammatory tissue is seen in the area. The blue stain is from the indigo carmine dye that stains the radial tear and the interpositional disc tissue in the tear, keeping it from healing

the native biomechanical relationship of the spine. Importantly, it does not burn any bridges for other more invasive surgical treatment options such as fusion or disc arthroplasty if the patient fails to achieve satisfactory pain reduction.

While more invasive than IDET, the advantages of direct endoscopic visualization allow targeted application of the RF probe, visual confirmation of collagen shrinkage/modulation, removal/ablation of nucleus pulposus and granulation tissue interposed within the annular tears, and evacuation of the toxic intradiscal metabolites and thermal byproducts via the continuous saline irrigation.

30.5 Disadvantages

The high learning curve transitioning from direct to endoscopic visualization has discouraged some surgeons from adopting a new surgical skill. Learning spinal foraminal anatomy and the recommended use of local rather than general anesthesia has limited the surgeon's surgical experience. There are currently few academic centers who have adopted endoscopic spine surgery as an integral part of the training curriculum, and interest has been restricted to surgeons willing to take time out to learn a new technique.

30.6 Indications

Patients with CLDP who have failed non-surgical treatment and who have no contraindications with foraminal access to the lumbar spine are candidates for this procedure. Nevertheless, while this is a minimally invasive operation, it has surgical risks, and is normally considered for patients who have few alternatives or after full disclosure of the risk/benefit ratio. Most surgical candidates are considered after extensive non-operative treatments including physical therapy, steroid injections, and pain management.

Discography will help the surgeon identify painful discs that may be amenable to treatment. Concordant pain during the discogram is important in identifying the disc as a pain generator, but the pattern of the pathoanatomy is also important. A single quadrant radial annular tear will be more amenable to treatment versus a circumferential annular tear. Equally important, discography can identify those patients that are pain sensitive and would not do well with any treatment. These patients have severe pain with simple needle insertion into the skin and/or lack a negative control level, feeling pain at discs normal on MRI and with normal discogram patterns.

Patients who meet the selection criteria for IDET or nucleoplasty would be candidates for SED and RF thermal annuloplasty.

30.7 Contraindications

Contraindications are considered to be relative. Severe lumbar degeneration has other causes of chronic back pain that may be predominantly from the facet or sacroiliac joint. Psychological and medical–legal factors need to be weighed against the potential benefits of any surgical procedure. Anatomic considerations for accessing the disc, severe instability, and stenosis are factors that will affect good results. Patients who are better candidates for a traditional stabilizing procedure should consider the likelihood of surgical success with traditional fusion when compared the microtherapy. The greatest risks are in patients who have chronic pain that defies any treatment and have severe disabling pain poorly explained by the pathoanatomy. When these patients have skipped lesions or multiple levels of discogenic pain or disc protrusions, there is no other viable surgical alternative. While most of these patients improve, and are grateful for any relief they can get, there is a small group of patients who may be unrealistic about the efficacy of the procedure or who react out of proportion to their pathoanatomy. Patients who cannot withstand the pain of needle insertion in the process of discography, for instance, may do poorly and may actually claim that the procedure, no matter how well it goes, made them worse. Postoperatively, especially in multiple level discogenic pain, after an initial period of improvement, disc subsidence causing foraminal stenosis or recurrent or subsequent disc herniation may occur. This may not be discovered until the recurrent symptoms become severe enough that a follow up MRI is performed. The patient may later elect to undergo a fusion or surgical procedure with another surgeon without further improvement. These patients are high risks for the surgeon if the medical–legal situation in his/her community is in crisis and if the procedure is not uniformly accepted by his/her peers who do not do the procedure. Partially, for this reason, the surgeon should do his/her own evocative discography and make the decision with respect to surgery. His/her experience with discography and its role in patient selection will be appreciated greater as he/she develops experience in the technique and in patient selection. His/her experience will then help with providing a more complete informed consent.

30.8 Patient's Informed Consent

Standard informed consent is obtained by informing the patients of their options for treatment, including no treatment or pain management only. The efficacy of the endoscopic technique should be discussed in the context of other surgical treatments available, including fusion. The surgeon's experience and his review of the literature should be discussed with the patient.

In addition to the standard risks of traditional posterior lumbar disc surgery, the surgeon should discuss the possibility of exiting nerve root dysesthesia. Since the surgical approach is adjacent to the dorsal root ganglion of the exiting nerve root, this may become irritated and result in dysesthetic pain along the exiting nerve root dermatome. This is usually in a different distribution to the patient's preoperative radiculitis since the traversing nerve root is typically affected, unless the patient has a foraminal herniation. We point this out because the patient may be concerned about a new area of symptoms. The patient can be reassured that the vast majority of exiting nerve root dysesthesia is temporary and has about a 5 – 15 % incidence [25, 35]. In traditional posterior transcanal discectomy traversing nerve root dysesthesia occurs, but is not considered an issue since the symptoms are in the same distribution as the preoperative radiculitis and it too is temporary. It is also difficult to differentiate the preoperative irritation to the traversing nerve root versus that caused by or aggravated by the surgical manipulation. Most patients are told that the nerve is recovering or "waking up" and it takes some time for it to become less irritated. A prospective study comparing a group of 100 consecutive patients undergoing selective endoscopic discectomy with a matched surgical group without neuromonitoring revealed no difference in dysesthesia or complication rate. While continuous EMG warned the surgeon of the proximity of surgical instruments to the exiting nerve, the use of local dilute anesthetic was equally safe in avoiding neuropraxia [45, 46]

Peers unfamiliar with electrothermal microtherapy may be inappropriately critical of the procedure because of lack of understanding of this emerging technology.

30.9 Surgical Technique

The patient is placed prone on the radiolucent hyperkyphotic frame (Kambin frame; US Surgical) with the arms away from the side of the body. Care is taken to line up the patient with the C-arm to ensure a perfect posterior-anterior (PA) and lateral view on the fluoroscopy. The spinous processes should be centered between the pedicles on the PA view and the endplates parallel on the lateral view. The surgical level must be centered to avoid parallax error. Anesthesia consists of local 0.5 % lidocaine infiltration, supplemented by Versed and fentanyl for conscious sedation.

30.9.1 Needle Placement

Accurate instrument placement is essential. This begins by directing an 18-gauge spinal needle into the posterior third of the disc via the posterolateral approach under fluoroscopic guidance. The needle entry point is approximately 12 cm lateral to the midline and parallel to the disc endplates on the lateral fluoroscopic view. The needle trajectory is typically 25 – 35° in relation to the coronal plane. Yeung has described a step-by-step protocol for optimal needle placement that takes into account the patient's individual anatomy [25, 35].

30.9.2 Evocative Chromo-discography

A confirmatory contrast discography is performed at this time. The following contrast mixture is used: 9 cc Isovue 300 with 1 cc indigo carmine dye. This combination of contrast ratio gives readily visible radio-opacity on the discography images, and intraoperative light blue chromatization of the pathologic nucleus and annular fissures which help guide the targeted fragmentectomy (Fig. 30.7).

Fig. 30.7. Evocative Chromo-discography. Discography is an integral part of microtherapy. Here, discography at L5-S1 identifies grade V tears causing concordant back pain and radicular pain in the L5 as well as the S1 dermatome. The contrast dye leaks out of the large grade V tears and outlines the exiting L5 and traversing S1 nerve

30.9.3 Instrument Placement

Insert a long thin guide wire through the 18-gauge needle channel. Advance the guide wire tip 1–2 cm deep into the annulus and then remove the needle. Slide the bluntly tapered tissue dilating obturator over the guide wire until the tip of the obturator is firmly engaged against the annulus. An eccentric parallel channel in the obturator allows for application of 0.5% lidocaine circumferentially around the guide wire into the annulus. This dilute solution is enough to anesthetize the annulus, but not the spinal nerves. Hold the obturator firmly against the annulus and remove the guide wire. Infiltrate the full thickness of the annulus through the obturator's center channel using 0.5% lidocaine.

The next step is the through-and-through fenestration of the annulus by advancing the bluntly tapered obturator with a mallet. Annular fenestration is the most painful step of the entire procedure. Advise the anesthesiologist to heighten the sedation level just prior to annular fenestration. Advance the obturator tip deep into the annulus and confirm on the C-arm views. Now slide the beveled access cannula over the obturator toward the disc. Advance the cannula until the beveled tip is deep into the annulus. Remove the obturator and insert the endoscope to get a view of the disc nucleus and annulus. The degenerated nucleus is preferentially stained blue from the indigo carmine while the annular fibers remain unstained allowing for selective discectomy.

Selective Endoscopic Discectomy is performed using the Yeung Endoscopic Spine Surgery system (YESS; Richard Wolf Surgical Instruments, Vernon Hills, IL) in order to selectively remove the nucleus pulposus in contact with and interposed within the annular tears. This is accomplished utilizing endoscopic pituitary rongeurs, larger hinged pituitary rongeurs, a suction-irrigation shaver, and a Ho:YAG side-firing laser. This creates the intradiscal working space, removes any nuclear tissue interposed in the annular tears, and allows visualization of the inner annular fibers.

The thermal annuloplasty portion of the procedure uses a bipolar RF electrode (Ellman Trigger-flex probe; Ellman International, Hewitt, NY). Under direct visualization the flexible Ellman RF probe ablates ingrown granulation tissue [14, 27, 28, 47, 48] and nerve endings already in the annular defects, and shrinks the annular openings (Fig. 30.8). Visualized tissue reaction to the RF modulation guides treatment length (Fig. 30.9). At the conclusion of the procedure, the annular fenestration is modulated by thermally shrinking the annular fibers. A foraminal injection of 40 mg triamcinolone or Depomedrol helps decrease the incidence of postoperative dysesthesia.

30.10 Postoperative Care and Complications

The patient is allowed to ambulate as tolerated, but twisting, lifting, stretching, and physical therapy is usually avoided for 3–6 weeks to allow the annular fibers to heal. The patient is given instructions on isometric lumbar stabilization exercises. Relief of back pain is immediate in 50% and gradual in the other 40%. About 10% may perceive worsening of their symptoms, especially if they experience postoperative dysesthesia.

As with arthroscopic knee surgery, the risks of serious complications or injury are low, about 1–3% in the author's experience. The usual risks of infection, nerve injury, dural tears, bleeding, and scar formation are always present as with any surgery. Transient dysesthesia, the most common postoperative complaint, occurs about 5–15% of the time and is almost always transient. Its cause is still incompletely understood and may

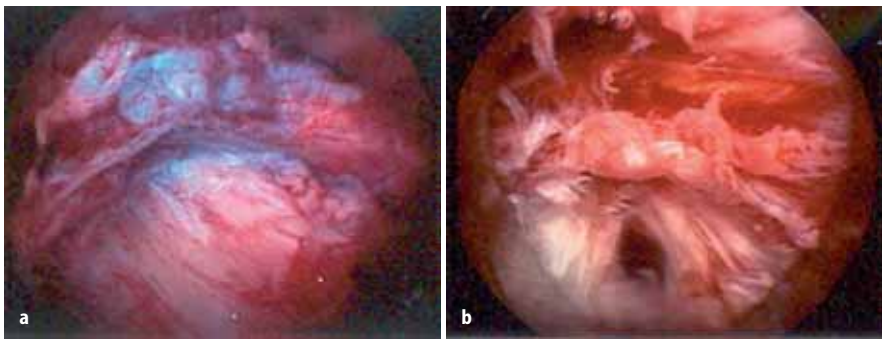

Fig. 30.8. a Inflammatory membrane. The grade V annular tear, stained blue by Evocative Chromo-discography, is surrounded by inflammation. Chemical irritation is the likely cause. **b** Blood in the foramen may look like inflammation. Bleeding in the epidural space can also look like inflammation and may be mistaken for an inflammatory membrane, but the condition of the surrounding tissue, as in this view of the fenestrated annulus, demonstrates relative healthy annular collagen. The annulus is bluntly dilated by the endoscopic obturator and cannula used to perform selective discectomy and thermal annuloplasty from the "inside" of the disc for a contained central disc herniation causing predominant back pain. Avoiding thermal annuloplasty of the outer annulus may help decrease the dysesthesia that can occur with ablation of the inflammatory membrane in the outer annulus and epidural space. Visualized thermal modulation of the annulus will contract the loose tissue. Central disc protrusions respond well to SED and thermal annuloplasty

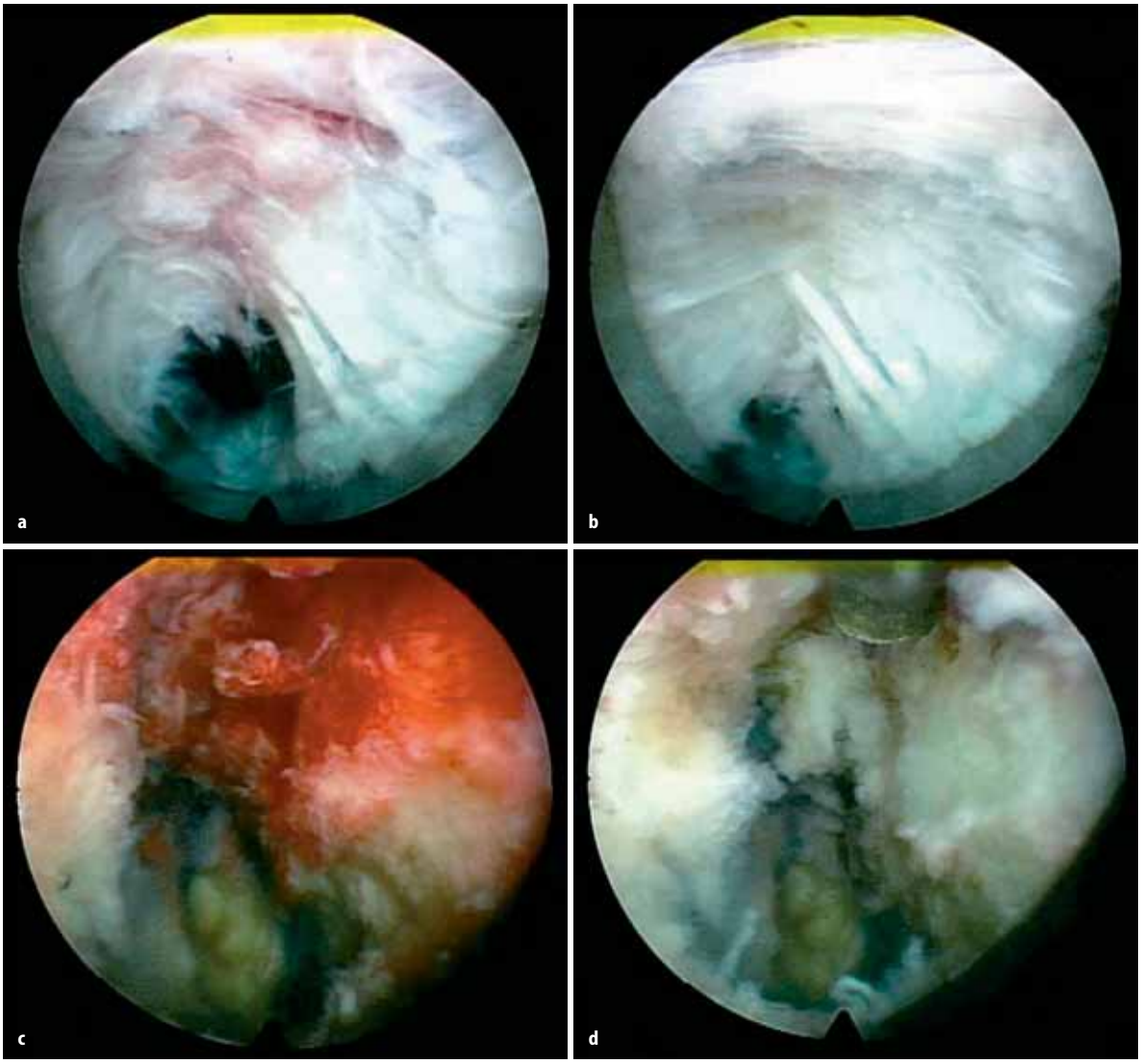

Fig. 30.9. a Granulation tissue in a recent annular tear associated with a bulging disc. **b** Granulation tissue is completely ablated and removed after visualized RF thermal treatment. The length of RF thermal treatment is determined by visual confirmation of ablated granulation tissue and shrinkage of the annular collagen. All interposed granulation has been removed. **c** Inflammatory membrane and granulation tissue in an annular tear. **d** After RF thermal treatment, the inflammatory membrane is ablated

be related to nerve recovery, operating adjacent to the dorsal root ganglion of the exiting nerve, or a small hematoma adjacent to the ganglion of the exiting nerve, as it can occur days or even weeks after surgery. Transient dysesthesia can occur even in cases where no adverse events were detected with continuous EMG and SEP neuromonitoring [45, 46]. Thus it cannot be completely avoided. The symptoms are like a variant of complex regional pain syndrome (CRPS), but less severe, and without the skin changes that accompany CRPS. Dysesthesia is readily treated by transforaminal epidural blocks, lumbar sympathetic blocks, and the use of Neurontin titrated up to 1,800 – 3,200 mg/day or Zonegran up to 400 mg/day if needed.

Avoidance of complications is enhanced by the ability to clearly visualize normal and pathoanatomy, the use of local anesthesia and conscious sedation rather than general or spinal anesthesia, and the use of a standardized needle placement protocol. The entire procedure is usually accomplished with the patient remaining comfortable during the entire procedure and should be done without the patient feeling severe pain except when expected, such as during evocative discography, annular fenestration, or when instruments are manipulated past the exiting nerve. Local anesthesia using 0.5 % lidocaine allows generous use of this dilute anesthetic for pain control and still allows the patient to feel pain when the nerve root is manipulated. Continu-

ous EMG and SEP can also help monitor and prevent nerve irritation. This usually correlates well with the patient's intraoperative feedback.

30.11 Results

A retrospective review of 113 consecutive surgical cases treating CLDP performed by one surgeon (A.T.Y.) was carried out between January 1997 and December 1999 [21]. There was a minimum 2-year follow-up. Selection criteria included failure of 6 months of non-surgical treatment in patients with chronic back pain without sciatica from lumbar disc herniation. Diagnoses included internal disc disruption, annular tear with high intensity zone, and degenerative disc disease. The subjects had surgery at only one or two disc levels.

Two outcome measures were used for clinical assessment: a surgeon-based modified MacNab method and a patient-based questionnaire. The results of this endoscopic procedure were each graded excellent, good, fair, and poor for the modified MacNab and the questionnaire methods. A mandatory poor result was given to any patient who had repeat spine surgery at the same level, had indicated dissatisfaction with the surgical result on the questionnaire response, or who felt the same or worse after the surgery.

Using the surgeon's assessment data, 83 patients (73.5%) were in the satisfactory outcome group. This group of patients included excellent, good, and fair categories. Excellent outcome was reported in 17 patients (15%); good in 32 patients (28.3%); and fair in 34 patients (30.1%). Thirty patients (26.5%) were determined to have poor results. The specific reasons were as follows: 12 patients were not improved after the endoscopic surgery, 8 patients had subsequent lumbar fusion; 7 patients had repeat lumbar endoscopic surgery; and 3 patients had lumbar laminectomy. Twelve patients in the poor category elected to have no further back surgery. Of the 18 patients who had secondary back surgery, 10 reported improvement after the subsequent operation. The satisfied group of patients would select the lumbar endoscopic surgery again in the future given the knowledge gained from their endoscopic experience.

Out of the 83 patients that returned the questionnaire, 64 (77.1%) reported satisfactory results with 14 (16.9%) rated excellent, 24 (28.9%) rated good, 26 (31.3%) rated fair, and 19 (22.9%) rated poor. The response rate to the questionnaire was only 73%, but the distribution of the patient grading was very similar to the surgeon-based assessment. In fact the questionnaire respondents have a higher percentage in the excellent group 16.9% (14/83) versus 15% (17/113) and lower percentage in the poor group 22.8% (19/83) versus 26.5% (30/113).

Perioperative adverse events from this study were low and included three cases of dysesthesia and one case of thrombophlebitis.

30.12 Critical Evaluations

Posterolateral transforaminal SED and RF thermal annuloplasty is a minimal access visualized surgical procedure. This chapter focuses on the role of annular defects as the first portal leading to pain sensitization. The authors' hypothesis on chronic pain sensitization is based on the following established findings. Nucleus pulposus (proteoglycan) and its metabolic by-products are known to be contact irritants to neural tissues [7–10]. End neural sensors, in a normal disc, are found in outer layers of the annulus fibrosus and juxta endplate zone [3, 4, 49]. These end sensors normally are shielded from direct contact with irritants by intact inner layers of annulus and cartilaginous endplates. Defects which develop in the inner annular layers or cartilaginous endplates potentially expose the end sensors to chronic direct contact with the proteoglycan. The chronic contact triggers a repair process in the annular defects resulting in ingrowth of new vessels [14], new nerve endings, and granulation tissue into the defects. The migrated cellular elements in the defects are in constant anatomic contact with the proteoglycan of the nucleus pulposus. Chronic direct contact between the irritants and end sensors is hypothesized to be the local process that initiates the back pain sensitization cascade. The interposed nuclear tissue may also prevent the annular tears from healing properly.

The treatment rationale for SED and RF thermal annuloplasty is based on the removal/ablation of the nucleus pulposus and granulation tissue interposed within the annular tears. The RF electrode heating process is also hypothesized to ablate the sensitized neural sensory endings that have grown into the fissures. The continuous saline irrigation during the endoscopic procedure flushes out the toxic metabolites within the disc. It also prevents the accumulation of any by-products of the thermal treatment.

This procedure thus has many theoretical advantages over some of the other percutaneous intradiscal procedures such as IDET and nucleoplasty (Coblation). IDET and Coblation rely solely on fluoroscopic guidance and are thus blind procedures. They are not designed to remove the interposed tissue within the annular tears or remove any by-products of their energy treatment.

Recent investigations on fusion outcome, with interbody implants, showed successful fusion rates, up to 98%, but the rate of clinical improvement ranged from 65% to 85% [16–20]. While our results fall within this

same range, comparison of results by the different surgical methods from the available literature data is not feasible because of the lack of uniformity in the important issues concerning this condition. Consensus is lacking in the definition of the condition, in patient selection criteria, in procedural details of provocation discography, as well as in the selection of outcome instruments. The available surgical options vary greatly in their invasiveness and in their hypothesized treatment mechanism [16–20, 48, 50–54]. A better understanding of the local intradiscal process that leads to pain sensitization is especially important, because all established operative procedures attempt to achieve one or more of the following: nucleus removal; changing the biomechanical properties of the interspace; and ablating annular neural sensors.

The authors believe, in the absence of a better objective diagnostic test, that evocative discography provides a gross estimation of the presence or absence of discogenic pain [13, 37, 40, 41, 55] and localizes the painful level(s). Surgeon-performed preoperative provocation (Evocative Discography) has patient selection advantages because the overall pain response in unsedated CLDP patients can be compared with the patient's overall reaction to needle insertion. The patient's behavior during the procedure provides additional clinical information that helps the surgeons with patient selection.

The authors emphasize that the posterolateral transforaminal SED technique has a steep learning curve and is equipment intensive. The technique was originally developed for nerve root decompression secondary to lumbar disc herniation and focal lumbar stenosis [25, 33–35, 56–58]. Mastery in spine endoscopy developed for the original purposes has enabled the authors to expand its capabilities, including paying attention to the annular fissures. As spinal endoscopy continues to evolve, other spinal pathology can be addressed by using the transforaminal endoscopic method. The roles of annular defects, and the cellular and molecular interactions within the defects are worthy of further investigation. Intradiscal endoscopy has established a window into intradiscal pathology.

30.13 Conclusions

Posterolateral transforaminal SED and RF thermal annuloplasty were used to interrupt the purported annular defect pain sensitization process, thought to be necessary in the genesis of CLDP. Lack of clinical benefit from the subject procedure did not degrade any subsequent surgical or non-surgical treatment options.

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