POSTEROLATERAL PERCUTANEOUS ENDOSCOPIC LUMBAR DISCECTOMY

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ABSTRACT

The technique and equipment for performing posterolateral percutaneous endoscopic lumbar discectomy has evolved dramatically in the past five years. The current level of proficiency brings endoscopic capabilities close to the capabilites of conventional transcanal open operations. The foraminal approach can be used not only for herniated discs, but also for degenerative conditions of the lumbar spine. The advantage of the foraminal endoscopic technique is the ability to reach, visualize, and treat certain intradiscal and foraminal pathologic lesions without destabilizing the posterior muscle column and facets. Intradiscal visualization is enhanced by chromo-discography combining non-ionic radiographic agents (isovue-300) with indigocarmine dye. This blue dye differentially stains degenerated nucleus.

The learning curve is steep, but once mastered, the surgeon is able to reach any pathologic lesion in the foramen, including noncontained disc herniations, foraminal stenosis, facet cysts, and annular tears.

Index Words:

Endoscopic discectomy

Skin window

Annular window

Disc inclination line

Nucleogram

Annulogram

evocative discography™

Selective endoscopic disectomy

Thermal annuloplasty

INTRODUCTION

Minimal access surgery for lumbar disc pathology was first independently reported by Kambin et al [1] and Hijikata [2] in 1973. The technique utilized a posterolateral approach to the foraminal zone bordered by the traversing nerve dorsally, the exiting nerve ventrally, and the endplate of the inferior vertebra caudally. The goal was to decompress nerve roots secondary to lumbar disc herniation. The early efforts were limited to a nonvisualized central discectomy to achieve an indirect decompression of the nerve roots [1,2,3]. Improvements in the surgical method and equipment evolved gradually over the next thirty years. In the last five years, the important major equipment improvements include: a high resolution rod lens operating endoscope with a working channel, beveled and slotted cannulas, a bipolar flexible high frequency/ low temperature radiofrequency (RF) electrode, and side firing Holmium Yttrium-Aluminum-Garnet laser [4]. An improved fluoroscopically guided approach method introduced by Yeung and reported by Tsou [5,6] outlined a consistent technique for entry into all lumbar posterior disc spaces including the L5-S1 level. These refinements have enhanced the capabilities of foraminal endoscopic discectomy to deliver surgical results similar to the results obtainable by traditional transcanal approaches for treating common lumbar disc herniations[5,6,7,8].

Minimal access posterolateral endoscopic intradiscal visualization with the available operating tools has introduced new operative capabilities. That includes selective nuclectomy and annuloplasty performed intradiscally.

The learning curve

Due to the steep learning curve, there are only a handful of endoscopic spine surgeons who practice posterolateral lumbar endoscopy as a major part of their practice. The obvious benefits for the patient, however, keep interest in the technique high**.** A few academic institutions are using the endoscopic system as an investigational tool. The learning curve for spinal endoscopy is steeper than the traditional microscopically assisted open procedures with or without the use of tubular retractors.

The first learning barrier is the percutaneous approach itself. The posterolateral or transforaminal approach to the disc through Kambin's triangle (figure showing the triangle) is not routinely taught in most spine surgery training programs. Precise needle placement and subsequent cannula and endoscope placement between the exiting and traversing nerve roots is needed to avoid patient discomfort and nerve injury in the awake patient. Eliciting a painful response from the patient can be intimidating to the spine surgeon not accustomed to operating on an awake patient. Patients will not tolerate multiple misguided needle passes and this will frustrate the surgeon as well. The posterolateral approach is routinely utilized by pain management and interventional radiology physicians when performing discograms, IDET, nucleoplasty, and transforaminal epidurals. With practice, spine surgeons can become accomplished to accessing the disc via the posterolateral approach. Yeung has developed a standardized method for optimal needle placement that should lower the initial learning curve.

The second learning barrier is becoming comfortable with the anatomic relationships within the foramen. All spine surgeons are trained in the posterior approach to the spine and are familiar with the anatomic relationships when viewed from this posterior approach. They are not accustomed to looking at the anatomy from the posterolateral or foraminal portal. The clear visualization provided by the newer fiberoptic endoscopes and a thorough understanding of the anatomic relationships help overcome this.

Another learning barrier is the ability to recognize anatomy on the video screen. Most neuorsurgeons do not have much if any experience using endoscopes. Most orthopaedic spine surgeons have used scopes for knee and shoulder surgery and are accustomed to looking at the two-dimensional video screen. The ability to move the scope and view structures from many vantage points rather than simply magnify the same view, help overcome this 2-dimensional viewpoint. Dedication to learning the technique and utilizing it are important in establishing and maintaining skill recognizing endoscopically viewed anatomy.

Once these learning barriers are overcome, surgeons competent with the technique will prefer posterolateral endoscopic spine surgery to the traditional posterior approach for most disc herniations.

Surgical Equipment

The most widely available system for posterolateral endoscopic discectomy is the Yeung Endoscopic Spine Surgery System (YESS) by Richard Wolf. The YESS system consists of the following instruments. (figure 2)

- Multichannel, 20° oval spinal endoscope with 2.7mm working channel and integrated continuous irrigation (inflow and outflow) ports
- Multichannel, 70° oval spinal endoscope
- 7mm working cannulas with various open slotted, beveled, and tapered ends
- 2 channel tissue dilator/obturator
- Specialized single and double action endoscopic rongeurs for visualized fragmentectomy
- Larger straight and hinged rongeurs for discectomy and targeted fragmentectomy
- Trephines for annulotomy and foraminoplasty
- Micro rasps, curettes, and penfield probes
- Annulotomy knife
- Flexible bipolar radiofrequency probe for hemostasis, thermal contraction of the annular collagen, and thermal ablation of the annular nociceptors (Ellman trigger-flex bipolar probe)

Adjunctive equipment

- Straight and flexible suction-irrigation shavers for discectomy (Endius MDS)
- Side firing Holmium-YAG laser (Trimedyne)
- Fluid pump for continuous irrigation
- Video endoscopy tower

OR Setup/ Patient positioning

Proper OR setup requires a radiolucent table with a hyperkyphotic frame, one C-arm, and a tower with the usual monitor for endoscopic viewing. Foot pedals controlling the radiofrequency probe, shaver, suction, C-arm, and laser should be ergonomically arranged. Required personnel include the anesthesiologist, scrub tech, circulator, C-arm technician and a surgical assistant if a biportal approach is planned. (figure 3)

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 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 _ percent local lidocaine infiltration, supplemented by versed and fentanyl for conscious sedation. The sedation is kept light enough to allow patient feedback if they experience any painful nerve root irritation.

Protocol for Optimal Central Needle Placement

Utilizing a thin metal rod as a radio-opaque marker and ruler, lines are drawn on the skin to mark surface topography for guidance in free hand biplane C-arm needle placement. These surface markings help identify three key landmarks for needle placement: the anatomic disc center, the annular foraminal window (centered within the medial and lateral borders of the pedicles), and the skin window (needle entry point). (figure 4)

- Utilizing a metal rod as radio-opaque marker and ruler, draw a longitudinal line over the spinous processes to mark the midline on the PA view.
- Draw a transverse line bisecting the targeted disc space to mark the transverse disc plane on the PA view. The intersection of these 2 lines marks the anatomic disc center.
- On the lateral fluoroscopic view draw a line on the patient's side representing the disc inclination plane. This line determines the cephalad/caudal position of the needle entry point. When drawing this disc inclination line, the tip of the metal rod should be at the lateral anatomic disc center and the rod should bisect and be parallel to the endplates.
- The distance from the rod tip to the plane of the posterior skin is measured by grasping the rod at the point where the posterior skin plane intersects it.
- This distance is then measured on the posterior skin from the midline along the transverse plane line.

- At the lateral extent of this measurement a line parallel to the midline is drawn to intersect the disc inclination plane line. This intersection marks the skin entry point or skin window for the needle.

The skin window's lateral location from the midline determines the trajectory angle into the foraminal annular window. Utilizing the above method, a 45 degree trajectory to the disc should place the needle tip in the true anatomic disc center. This is good for a central nucleotomy to decompress the disc.

Since most of the pathology being treated is located posteriorly, however, placement in the posterior one third of the disc is optimal. Thus one needs to move the skin window 1-2 cm laterally for the optimal needle placement into the posterior one third of the disc. This allows one to avoid the facet joint with a shallower needle trajectory (about 30 degrees in relation to the coronal plane) to the disc.

Alternatively one can place the rod tip at the anterior portion of the disc when measuring the disc inclination plane on the lateral fluoroscopic view. This produces a longer measurement from the rod tip to the posterior skin plane, thus placing the skin window more lateral. This is the authors' preferred method. This coordinate system of finding the optimal anatomical landmarks for instrument placement will help decrease the steep learning curve for needle placement and eliminate the less accurate "down the tunnel" method favored by radiologists and pain management physicians.

The positive disc inclination plane of the L5-S1 disc is noteworthy. A steep positive inclination line (lordosis) will position the optimal skin window more cephalad from the transverse plane line, avoiding the “high iliac crest”. A flatly inclined L5-S1 disc will position the optimal skin window with the iliac crest obstructing the trajectory of the needle. The skin window will have to start more medial to avoid the iliac crest, and sometimes the lateral _ of the facet joint must be resected to allow for posterior needle placement in the disc.

The first neutrally aligned disc inclination plane is usually at L4-L5 or L3-L4. A neutrally aligned disc inclination plane is in the same plane as the transverse plane line, thus the skin window is in line with the transverse plane line. A negatively inclined disc, often at L1-L2 and L2-L3, places the skin window caudal to the transverse plane line.

Needle Placement

Infiltrate the skin window and subcutaneous tissue with one half percent lidocaine. Insert a six inch long, 18 gauge needle from the skin window at a 25-30 degree angle from the coronal plane (reciprocal of 65-60 degrees from the parasagittal plane), anteromedially toward the anatomic disc center. Infiltrate the needle tract with one half percent lidocaine as you are advancing the needle. The superficial portion of the needle trajectory is usually outside of the c-arm viewing perimeter on the PA view. Once the needle tip is visible within c-arm viewing perimeter, tilt the c-arm beam parallel to the disc inclination plane, the Ferguson view. This allows one to visualize the advancing needle in the true disc inclination plane. Advance the needle toward the target foraminal annular window. If minor directional adjustments are necessary, use the plane of the needle bevel and hub pressure to navigate (ie. If the needle bevel is facing dorsal, the needle will tend to move ventral when advancing it). At the first bony resistance or before the needle tip is advanced medial to the pedicle; turn the c-arm to the lateral projection. Do not advance the needle tip medial to the pedicle during the initial approach. Doing so risks inadvertent traversing nerve root and dural puncture.

Most frequently the first bony resistance encountered is the lateral facet. Increase the trajectory angle to aim ventral to the facet and continue the approach toward the foraminal annular window. Turning the needle bevel to face dorsal helps the needle tip skive off the undersurface of the facet. The c-arm lateral projection should confirm the needle tip's correct annular location. In the lateral view the correct needle tip position should be just touching the posterior annulus surface. In the postero-anterior view the needle tip should be centered in the foraminal annular window. The above two views of the c-arm confirm that the needle tip has engaged, the safe zone, the center of the foraminal annular widow.

While monitoring the postero-anterior view, advance the needle tip through the annulus to the midline (anatomic disc center). Then check the lateral view. If the needle tip is in the center of the disc on the lateral view you have a central needle placement, which is good for a central nucleotomy. Ideally the needle tip will be in the posterior one third of the disc indicating posterior needle placement. This is ideal for accessing most herniations.

Evocative Chromo-discography

Perform confirmatory contrast discography at this time. The following contrast mixture is used: nine cc of Isovue 300 with one cc of indigo carmine dye. This combination of contrast ratio gives readily visible radio-opacity on the discography images, and intra-operative light blue chromatization of pathologic nucleus and annular fissures which help guide the targeted endoscopic fragmentectomy.

Chromo-discography is an integral part of posterolateral selective endoscopic discectomy. The indigo carmine preferentially stains the acidic degenerated nucleus pulposus. This helps orient the surgeon to the endoscopic anatomy and selectively remove the herniated and unstable nucleus pulposus. The surgeon can follow the blue stained tissue to the annular tears and the herniation tract.

The ability of discography to evoke a concordant painful response is also helpful to confirm the disc as a pain generator. The literature on discography is currently considered controversial. It is controversial partly because of the high inter-observer variability by discographers in reporting the patient's subjective pain as well as the ailing patient's inability to give a clear response, especially if pain response is altered by the use of analgesics or sedation during the procedure. The surgeon who is accomplished in endoscopic spine surgery should do the discography himself in order to decrease the inter-observer variability in interpreting the patient's response and thus better select for appropriate patients.   One of the main uses of discography is to exclude patients who are overly pain sensitive and thus poor surgical candidates.

Instrument Placement

Insert a long thin guide wire through the 18 gauge needle channel and into the disc. Remove the needle and slide the bluntly tapered tissue dilating obturator over the guide wire until the tip of the obturator is firmly engaged in the annular window. An eccentric parallel channel in the obturator allows for four quadrant annular infiltration using small incremental volumes of one half percent lidocaine in each quadrant, enough to anesthetize the annulus, but not the nerve roots. Hold the obturator firmly against the annular window surface and remove the guide wire. Infiltrate the full thickness of the annulus through the obturator's center channel using lidocaine.

The next step is the through-and-through fenestration of the annular window 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 in the annular window. Remove the obturator and insert the endoscope to get a view of the disc nucleus and annulus.

Alternatively if you are worried about further extruding a large disc herniation or you want to inspect the outer annular fibers before fenestrating the annulus, the surgeon can engage the outer annulus with the blunt obturator.

Then the beveled cannula is advanced over the obturator to the annulus. The obturator is removed and the endoscope is inserted. The outer annular fibers can be inspected to ensure that no neural structures are in the path of the cannula prior to the annulotomy. Then an annulotome or a cutting trephine can be used for the annular fenestration under direct vision. Prominent disc tissue can be removed prior to entering the disc with the cannula.

The foraminal annular window is an easily identifiable c-arm and intraoperative anatomic landmark and is the starting location for endoscopic disc excision. Through the endoscope, the surgeon may see various amounts of blue stained nucleus pulposus. The general purpose access cannula has a bevel hypotenuse of 12 mm and outside diameter of 7 mm. When the cannula is slightly retracted to the midstraddle position in relationship to the annular wall, the wide angle scope visualizes the epidural space, annular wall and the intradiscal space in the same field.

Performing the Discectomy

The basic endoscopic method to excise a non-contained paramedian extruded lumbar herniated disc via a uniportal technique is described here. First enlarge the annulotomy medially to the base of the herniation with a cutting forcep. The side-firing Holmium-YAG laser can also be utilized to enlarge and widen the annulotomy. This is performed to release the annular fibers at the herniation site that may pinch off or prevent the extruded portion of the herniation from being extracted. Directly under the herniation apex a large amount of blue stained nucleus is usually present, likened to the submerged portion of an iceberg. The nucleus here represents migrated and unstable nucleus. The endoscopic rongeurs are used to extract the blue-stained nucleus pulposus under direct visualization. (Figure 5) The larger straight and hinged rongeurs are used directly through the cannula after the endoscope is removed. Fluoroscopy and surgeon feel guides this step. By grabbing the base of the herniated fragment, one can usually extract the extruded portion of the herniation. Initial medialization and widening of the annulotomy reduce the prospect of breaking off the apex of the herniation. The traversing nerve root is readily visualized after removal of the extruded herniation. (figure 6,7,8)

Next perform a bulk decompression by using a straight and flexible suction-irrigation shaver (Endius MDS). This step requires shaver head c-arm localization before power is activated to avoid nerve/dura injury and anterior annular penetration. The cavity thus created is called the working cavity. The debulking process serves two functions. First it decompresses the disc, removing the unstable nucleus material to prevent future reherniation. Secondly it creates a working space to visualize the inner layers of the posterior annulus, annular clefts/tears, the herniation tract, and any residual herniated nucleus pulposus.

Inspect the working cavity. If a non-contained extruded disc fragment is still present by finding blue stained nucleus material posteriorly, then these fragments are teased into the working cavity with the endoscopic rongeurs and the flexible radio-frequency trigger-flex bipolar probe (Ellman) and removed. Creation of the working cavity allows the herniated disc tissue to follow the path of least resistance into the cavity. The flexible radio-frequency bipolar probe is used to ablate any ingrown granulation tissue and contract and thicken the annular collagen at the herniation site. It is also used for hemostasis throughout the case.

The vast majority of herniations can be treated via the uniportal technique. Sometimes for large central herniations the disc needs to be approached from both sides by incorporating a biportal technique.

Complications and avoidance

The usual risks of infection, nerve injury, dural tears, bleeding, and scar-tissue formation are always present as with any surgery. Dysesthesia, the most common postoperative complaint, occurs approximately 5%-15% of the time, and is almost always transient. Its cause remains incompletely understood and may 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. One possible cause of the new symptoms, could be attributed to a contact irritant caused by leakage of cytokines and proteoglycan from the annular opening. To prevent this, an added step of annulotomy sealing is used at the conclusion of the procedure in order to stop or reduce leakage from within the disc space. It cannot be avoided completely, and has occurred even when there were no adverse intraoperative events, even with continuous electromyography (EMG) monitoring. The symptoms are sometimes so minimal that most endoscopic surgeons do not report it as a “complication.” The more severe dysesthetic symptoms are similar to a variant of complex regional pain syndrome, but usually less severe, and without the skin changes. Postoperative dysesthesia is treated with transforaminal epidurals, sympathetic blocks, and the off-label use of gabapentin (Neurontin®, Pfizer, Inc., New York, New York, USA) titrated to as much as 1800-3200 mg/day. Gabapentin is FDA-approved for post-herpetic neuralgia, but effective in treatment of neuropathic pain.

Bowel injury or large vessel injury is extremely rare, but possible if the suction-irrigation shaver penetrates the contralateral annulus from an incompetent annulus or from a defect left after removing a disc herniation that has extruded through the annular wall. Careful intra-operative fluoroscopic localization and “feeling” the contralateral annulus with the instrument prior to activating it will help prevent the shaver from advancing past the contralateral annular wall.

Avoidance of complications is enhanced by the ability to visualize normal and patho-anatomy clearly, and use of local anesthesia and conscious sedation rather than general or spinal anesthesia. 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 discography, annular fenestration, or when instruments are manipulated past the exiting nerve. Local anesthesia using .50% lidocaine permits generous use of this dilute anesthetic for pain control yet allows the patient to feel pain when the nerve root is manipulated.

Lesion specific endoscopic technique

The endoscopic technique described in the previous section is applicable to most lumbar disc pathology. Additional techniques are introduced below for special situations.

Contained central protrusion

Instrument placement in the posterior disc is important to access the central disc protrusion. It is not necessary to medialize the annulotomy since there is not an extruded fragment. The working cavity is created directly deep to the central disc protrusion. Working from directly underneath the herniated fragments, the flexible suction-irrigation shaver is used to reduce the thickness of the herniated fragment using a back and forth sweeping motion. The 4.5 mm diameter shaver does not allow simultaneous intradiscal visualization in the uniportal approach. When slight blood tinged shaving debris appears in the suction tubing, stop the shaving. The pink material signals that the inflamed layer of the annulus has been reached. Further thinning of the annulus may still be necessary if the remaining annular bulge is hard and unyielding.

Extra-foraminal herniation.

Using the standard ipsilateral approach trajectory for extra-foraminal disc herniations is usually sufficient to remove extra-foraminal herniations since the cannula can be leveraged against the lateral facet to reach the laterally postioned disc fragment. The approach trajectory angle can also be increased to a 45 degrees so the surgical instruments are placed slightly more lateral. Because the exiting nerve and disc herniation may be in the path of the obturator and cannula, the surgeon may opt to place the endoscope in the region of the herniation before fenestrating the annulus. Either the exiting nerve or the herniation will be the first structure encountered. Here, visualization of the foraminal contents will dictate the fragment extraction technique.

<u>Chronic lumbar discogenic pain</u>

There is no consensus as to the most appropriate surgical treatment for chronic lumbar discogenic pain. Surgical options range from non-visualized intradiscal electro-thermal therapy to disc prosthesis or fusion. Endoscopy introduces a visualized selective nuclectomy and annuloplasty option. The technique described below uses a bipolar radio-frequency probe to ablate the granulation tissue and neural sensor endings in the annular defects and then close the defects.

Excavate a working tunnel (figure 6) to reach the annular defects as demonstrated by dye leakage on the discogram images and guided by the intradiscal blue staining. Proceed to establish a minimal working cavity directly deep to the annular defects (figure 6). Selective nuclectomy is performed at this step. Use the bipolar radiofrequency probe to ablate the granulation tissue and the nerve endings that have reached into the annular defects surfaces (figure 7). The same RF energy also reduces or closes the defects by modulating the collagen fibers.

SUMMARY

Posterolateral lumbar endoscopy introduces a visualized method for minimal access to the disc space as an alternative in the surgical management of conventional lumbar disc herniations. The technique has close overlapping capability as compared with traditional posterior trans-canal open methods. In addition, this endoscopic approach allows for the visualization of intradiscal pathology, and the surgical capacity to perform selective nuclectomy and annuloplasty as a new method in treating chronic lumbar discogenic pain.

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Legend

Figure 1

The procedure is carried out in an operating room, under aseptic conditions, using local anesthesia and conscious sedation. Free hand c-arm biplane guidance method is used. Two basic c-arm projected images are utilized, postero-anterior and lateral projections. Both views require parallelism of the x-ray beam to the target end-plates. When the intervertebral disc is not perpendicular to the floor, the c-arm tube is tilted until the beam (dotted line) is parallel to the L5-S1 disc end-plates (Ferguson view). L is the length measured on the thin metal rod from center of the disc to the posterior skin surface.

Legend

Figure 2

Axial view needle trajectory. From the skin window aim the approach needle toward the disc center at 25-35 degrees in the frontal plane. The path is medial to quadratus lumborum. Thus avoids inadvertent visceral penetration. The trajectory places posterior one third of the disc and the epiannular space within reach of the operating tools. Use more obtuse angle if epiannular procedure is not needed. Enter the disc through the annular window and place the needle tip in midline. In the lateral projection the needle tip need not pass the midpoint of the disc. Provocation contrast/blue dye discography is performed in this position. ES is erector spinae. QL is quardratus lumborum. P is psoas.

Legend

Figure 3

The method of free hand, biplane, c-arm guided approach to the lumbar disc.

Figure 3A, PA view. Use a thin metal rod to locate and mark midline. Mark transverse line that bisects each disc with x-ray beam parallel to end-plates. Where the lines intersect is the center of the disc as marked by quadrant circle. The dotted circle at L4-L5 level is the foraminal annular window, the safe entry point into the disc. The foraminal window can be enlarged and medialized under endoscopic vision, as illustrated at the L5-S1 level.

Figure 3B, lateral view. Plot skin window location by finding length L. Length L is measured by aligning the thin metal rod along the target disc bisecting inclination line. Length L is the measurement from the center of the disc to the posterior skin surface.

Figure 3C, PA Fergusen view of the L5-S1 disc. The skin window is located length L from the midline on the transverse disc bisecting line. The approach trajectory to the L5-S1 disc foraminal window is cephalad to the iliac crest due to lordotic inclination of this disc. This figure shows the needle is cleared of the iliac crest.

Legend

Figure 4

Axial view. Endoscopic excision of paramedian noncontained lumbar disc herniation. From the foraminal window, the working tunnel (open arrow) and working cavity (solid arrow) are excavated. The biting forceps is used to incise the annular collar, as illustrated. The extruded nucleus fragment is released and pulled out first into the working cavity, then out through the endoscope working channel, through the cannula if the disc fragment is too large.

Legend

Figure 5

Lateral view. Excision technique for a massive noncontained herniation, open hinged door type. A working tunnel and working cavity are excavated in close proximity to the posterior vertebral corners. The annulus fibrosus is detached from its remaining vertebral corner insertion by using a side firing Holmium yttrium-aluminum-garner laser beam. Then the freed herniated nucleus/ annular fragment is pulled out via the working cavity and tunnel.

Legend

Figure 6

Axial view. Technique of selective nuclectomy for chronic discogenic pain. Degenerated nucleus pulposus and the granulation tissue in the annular defects are blue stained using 10-20% indigocarmine. Excavate working cavities (solid arrows) directly deep to the annular defect clusters using a motorized shaver. A flexible power shaver is illustrated. The working cavities are connected by a working tunnel (open arrow).

Figure 7

Axial view. Technique of bipolar radio-frequency electrode ablation of granulation tissue and intraannular nucleus material for chronic discogenic pain. Adjacent to the working cavities, blue stained annular defects are visualized by the endoscope. Use the flexible bipolar radiofrequency probe to ablate the blue stained material in the annular defects. The neural sensor endings that have grown into the defect surfaces are also ablated. The same energy will reduce or close the defects.