

Laser Assisted Arthroscopic Microdisectomy

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ABSTRACT

Study Design:

A combined technique of percutaneous laser disc decompression (PLDD) and arthroscopic microdisectomy (AMD) was used to treat symptomatic lumbar disc herniations.

Objectives:

(1) To evaluate the effectiveness and patient satisfaction of the combined technique of PLDD and AMD, (2) to describe the technique, (3) to determine whether back pain or leg pain as a major presenting complaint affected the success rate.

Summary of background data:

Minimally invasive techniques have been used separately with different success rates.

The combination of more than one technique which might affect the success rate has not been fully explored.

Methods:

Eighty consecutive patients were evaluated by one author (FAH), who did not participate in the surgery. Follow up ranged from two to four and one-half year. Evocative chromodiscography precedes percutaneous fenestration of the lumbar disc to label the degenerative disc material. KTP laser created a bloodless intradiscal working cavity. A posterior fragmentectomy was then performed by uniportal or biportal technique. MacNab criteria, a visual analog scale, and a patient questionnaire were employed for clinical assessment.

Results:

Sixty-nine patients (89%) indicated they were satisfied with the procedure and would recommend it to others. Good or excellent results were determined in 56/80 (70%) patients. Predominant leg pain patients had a success rate of 80%. Patients who had mostly back pain had a success rate of 63%. Postsurgical pain improvement on the visual analog scale averaged 7.2.

Conclusion:

The combined technique of PLDD and AMD is a safe and effective surgical method for the treatment of lumbar HNP, with high patient satisfaction.

(Key words: laser, disc herniation, minimally invasive spine surgery, sciatica, back pain.

MINI ABSTRACT (PRECIS)

A combined technique of percutaneous laser disc decompression and arthroscopic microdiscectomy was used to treat symptomatic lumbar disc herniations. The procedure provides better decompression and can target the herniated fragment under direct arthroscopic visualization. Patients who presented with predominantly back pain had less successful resolution of their symptoms than those who presented primarily with sciatica.

No Funds have been or will be received in support of this study.

Device status Category (11)

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INTRODUCTION

Minimally invasive operations are being increasingly used in selected cases as an alternative to traditional surgery for treatment of herniated lumbar intervertebral discs and symptomatic lumbar disc disease ([30,12](#)). Different techniques and instrumentation have been used including chemonucleolysis (CNL), percutaneous lumbar discectomy (PLD), arthroscopic microdiscectomy (AMD), automated lumbar discectomy (nucleotomy), percutaneous laser disc decompression (PLDD), radiofrequency thermal coagulation (RFT) and intradiscal electrothermal therapy (IDET). These procedures share several advantages over open discectomy. Patients are awake during the procedure, given only light sedation, and are anesthetized with only local anesthesia. The patient is discharged home the same day and allowed to ambulate. Minimal morbidity occurs, as there is no violation of the spinal canal. Also, no bony or ligamentous elements are removed which might result in subsequent segmental instability and no significant epidural or peri-neural scarring when compared with open technique. These advantages translated into shorter recovery time, fewer complications, and satisfactory surgical outcome ([1 - 8,17,20](#)).

Smith ([9](#)) reported enzymatic dissolution of nucleus pulposus (using chymopapain injection) in humans in 1964. Significant concern arose about complications including anaphylaxis, lower back pain, stiffness, and neurological complications. The ability to directly visualize the effect of chymopapain via arthroscopy of the nucleus pulposus and the incorporation of peri-operative discography has mitigated much of the risk. In 1975 Hijikata ([10](#)) described percutaneous lumbar discectomy using specially designed cannula and rongeurs to remove disc material percutaneously through the posterolateral approach. In 1983 Kambin ([11,13](#)) used an arthroscope to visualize the interior of the disc and later developed a percutaneous biportal technique to remove herniated disc fragments under direct visualization. Onik ([29](#)) developed an automated suction cutting instrument inserted percutaneously to decompress the lumbar intervertebral disc. Using this principle, Choy and Ascher ([14,15](#)) in 1987 used laser (Nd:YAG) to evaporate part of the nucleus pulposus to decompress the herniated lumbar intervertebral discs. Different types of lasers have been used to treat contained herniated lumbar intervertebral discs, but only the Ho:YAG and KTP lasers are FDA approved. Radiofrequency probes and the more recently introduced intradiscal electrothermal therapy (IDET) utilizing thermoelectric catheters ([1,2,3](#)) are being used to treat

chronic discogenic lower back pain unresponsive to conservative treatment. Such patients have too often been treated with surgical arthrodesis when conservative measures fail.

The present study describes the combined technique of AMD and PLDD, determines the effectiveness in the treatment of lumbar HNP and the extent of patient satisfaction, and further analyzes the success rates with regard to the dominant presenting symptom of back or leg pain. (discogenic vs. radicular pain).

MATERIALS AND METHODS

Eighty patients came to surgery with the combined technique of AMD and PLDD (mean age: 41.9 years, range 25 - 69 years). The distribution of the operated levels were as follows: L2-3 (2); L3-4 (12); L4-5 (28); L5-S1 (21); L4-5 and L5-S1 (17). All cases were operated on by one author (ATY). Clinical examination and pain questionnaires were conducted preoperatively and postoperatively. Inclusion criteria in this study were: 1) confirmed lumbar disc herniation by history, clinical examination with neurological finding and/or tension sign in the lower extremity, 2) radiological findings of lumbar disc herniation on MRI, CT, or discography, and 3) failed conservative treatment for at least 6 weeks after beginning of symptoms.

The anesthesia was conscious sedation with the patient in prone position, and local xylocaine 1% was injected into the skin and subcutaneous tissue and fascia. IV antibiotic (1 gm of cephalosporin) was given immediately prior to starting the procedure. Fluoroscopic control verified exact needle placement in the center of the involved disc via the posterolateral approach. Indigo carmine dye and isovue 200 were injected in the disc space as part of evocative discography. Concordant symptoms to pre-operative radiological diagnosis of the involved level were considered confirmatory to site of herniation and cause of pain with a negative control discography of a level below and/or above the involved disc.

Surgical Technique

The laser disc ablation was started first by delivering energy at 10 watts (1 seconds on, 1 seconds off to permit heat dissipation). Lasering was paused when the patient reported discomfort from the heat created by the laser. A maximum of 1800 joules was utilized per disc. An adequate intradiscal working cavity was created. The arthroscopic microdiscectomy began with introduction of the scope into the disc space after measuring the appropriate angle of entry. Prior to annular fenestration, the scope visualized the triangular working zone structures to be certain that the sharp fenestration instrument would not injure the nerve root or dura. The scope was then introduced into the created intradiscal cavity. Deflecting sheath and flexible forceps were used to target the herniation fragment. The indigo carmine dye stained the degenerative nuclear material blue-green in color. Pigment also enhanced the effect of the KTP laser on degenerative nuclear disc material while normal nucleus and annular fibers remained relatively unstained.

After the herniated fragment was retrieved, the disc space was further inspected for any loose fragments and irrigated with a normal saline solution containing 80 mg of Gentamycin per liter. The patient was transferred to the recovery room, allowed to ambulate, and then discharged home on the same day.

Follow up and reevaluation were done by one author (FAH), who did not participate in the surgery. Patients were personally interviewed and examined. Follow up ranged over a period of two to four and one-half years. Clinical examination, chart review, x-rays, MRI and CT scans were also

reviewed for each patient. MacNab criteria (excellent, good, fair, poor) were in use. The visual analogue scale (0 - 10) was also utilized for preoperative and postoperative pain evaluation, severity of symptoms and the dominant presenting complaint of lower back pain or leg pain was noted. Improvement was considered immediate if the majority of the patient's symptoms improved within 24 hrs, or delayed if there was gradual resolution of symptoms over a period of days or weeks. Subjective evaluation and postoperative satisfaction for the procedure and whether they would recommend it to other patients with a similar condition were also inquired.

RESULTS

Sixty-nine patients (89%) said they were satisfied with the procedure and would recommend it to other patients who have similar conditions. Successful (Good or excellent) results were determined in 56/80 (70%) of patients. This population included similar numbers of workers' compensation patients, litigation patients, and private patients. 24/80 (30%) were rated fair or poor. Thirty one (31) patients who presented with predominant symptom of leg pain had a success rate of 80% (good/excellent), and forty nine (49) patients who had predominantly lower back pain was 63%, good or excellent. Eight patients (10%), who did not improve after the procedure and continued to have significant symptoms, underwent subsequent open discectomy. Cause of failure was either failure to completely remove an extruded fragment or unrecognized foraminal stenosis. Post-operative pain improvement on the visual analogue scale averaged 7.2. Twenty-eight patients (50% of the good or excellent rated group) had immediate improvement of symptoms, while the remaining 28 patients had gradual resolution of symptoms over a period of days or weeks. Post-operative complications included only two cases of transient paresthesia of the lower extremity. Both cases resolved spontaneously.

DISCUSSION

Minimally invasive techniques using chemical (chymopapain), physical (lasers, radio-frequency probes and thermoelectric catheters), or mechanical methods (Percutaneous Lumbar Discectomy, Automated Nucleotomy, Arthroscopic Microdiscectomy)) for the treatment of symptomatic disc herniation share a common physical principle which is in a closed compartment like the intervertebral disc a small decrease in intradiscal volume will result in disproportional large drop in intradiscal pressure(17,18). Central decompression might result in regression of a contained disc herniation and relief of mainly radicular symptoms due to neural compression. Other factors induced by these techniques play a major role in reducing symptoms not only the radicular symptoms but also back pain. The combination of techniques enables the operating surgeon to treat larger herniations, not amenable to central decompression, by targeting the herniation site under direct vision. In addition the back pain component of internal disc derangement can be ameliorated by radiofrequency probes and intradiscal thermoelectric catheters. Lasers have been in clinical use for the treatment of herniated lumbar intervertebral discs for more than a decade. Only Ho:YAG and KTP lasers are FDA approved. The lasers produce photothermal action on tissues and body fluids. The energy of this monochromic synchronized light beam is absorbed by the disc tissues and converted to heat. Heat causes coagulation of proteins above 45°C, shrinking of collagen at 65°C, and boiling of water at 100°C(19). Higher temperature will result in vaporization, ablation, carbonization and charring. Heterogeneity of biological tissues results in variable absorption of laser. Poor absorption of laser will result in deeper penetration of the beam, generalized disc heating and ineffective ablation. The KTP laser wavelength (0.532 microns) is in the blue green visible light spectrum and has been used in ophthalmology to treat retinal lesions and in dermatology to treat pigmented and vascular skin lesions. The absorption is significantly enhanced by the presence of pigments like hemoglobin or melanin (16). Absorption also increases

in presence of indigo carmine; a blue green vital dye, which is taken preferentially by the degenerative nucleus pulposus while normal tissue remain relatively unstained.

Laser creates an intradiscal bloodless working cavity(20). Annular fibers in close proximity to the ablation site, and the remaining nuclear material will shrink. Heat above 65o C will convert the triple helix of the collagen fibers into a shorter random coil. Shrinkage of the annular fiber may help stabilize the ablated disc level and reduce the annular bulge associated with disc height loss in degenerated discs (26). Anatomic improvement has been noticed in postoperative MRI at the herniation site (17). Removal of stained degenerative disc tissue primarily allows the surgeon to be more selective in targeting the herniation site under direct vision.

The mechanism of pain in HNP may not only be due to mechanical compression by the herniated fragment but also caused by chemical irritation of the nerve root and nerve endings in the outer annular fibers (21). Painful degenerated discs have been shown to be innervated by deeper free nerve endings rather than the superficial annular innervation of healthy discs (24). The nucleus tissue cells are capable of producing several inflammatory and noxious substances like phospholipase A2, PgE2, matrix metalloproteinases, nitric oxide and interleukines (21,22). Degenerated discs have circumferential and radial fissures, which provide communication between the nuclear space and outer annular layers. In non-contained disc herniation, the discogram shows clear and direct seepage of the dye into the epidural space. Inflammatory mediators from inside the disc space can follow similar paths. Compressed, irritated and inflamed nerve roots are very sensitive to stretching or mobilization, which causes severe pain. Dorsal root ganglia usually located in the neural foramen region are especially susceptible to such effects. The dorsal root ganglia have more extensive response when inflamed, compressed, or chemically irritated and fire spontaneously for prolonged periods of time even when the original stimulation has been removed. Adequate ablation and heating of the nuclear tissue will eliminate the inflammatory mediator source from the nucleus pulposus like the phospholipase A2, PgE2 and IL6 and consequently remove the chemical component of neural irritation.

Five mechanisms explain the resolution of back and leg pain in patients with a herniated lumbar disc: 1) decompression of the disc space, 2) ablation of the source of the inflammatory mediators, 3) coagulation of the free nerve endings in the annulus 4) sealing of the annular fissures, and 5) stabilizing disc space motion segment.

CONCLUSION

The KTP laser creates a bloodless intradiscal working cavity which helps in better visualization and retrieval of the herniated disc fragment. The heat generated by the laser may have a positive effect in controlling the lower back pain component due to the herniated disc. The arthroscopic part of the procedure ensures safe access to the disc space and retrieving extruded fragments not possible to be removing by central nucleotomy or blind evacuation of the herniation site. The combined technique of PLDD and AMC is safe, effective, and associated with high patient satisfaction.

ACKNOWLEDGMENT

The authors wish to express their thanks to Martin H. Savitz, M.D., F.A.C.S., F.I.C.S., F.R.C.S.(US), who reviewed the text for publication.