Minimally Invasive Percutaneous Hydrodiscectomy: Preliminary Report

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Objective: The standard of care for surgical treatment of degenerative disc disease (DDD) is open microdiscectomy, but various minimally invasive procedures have been introduced to treat DDD. For example, there are many techniques such as endoscopic discectomy (with or without laser), intradiscal electrothermal therapy (IDET), nucleoplasty, automated percutaneous discectomy (APLD), etc. Among them, some surgical techniques are still used and others have disappeared as a result of their respective advantages and disadvantages. This paper will report the feasibility of percutaneous hydrodiscectomy.

Methods: A total of 13 patients who underwent hydrodiscectomy from November 2007 to March 2008 at 3 university hospitals and 2 general hospitals, respectively, were evaluated. Preoperative symptoms were low back pain with radiculopathy in 12 cases and back pain only in one case. All of the patients had a soft disc herniation. Patients who had a sequestered disc fragment and instability in preoperative dynamic roentgenogram were excluded.

Results: There were 13 patients: 10 male and 3 female patients. Mean age was 38.1 years old. The mean duration of the symptoms and conservative treatment period was 18.7 ± 18.3 months and 4.7 ± 1.98 months, respectively. Mean follow-up period was 5.5 ± 1.3 months. Preoperative back and leg visual analogue scale (VAS) scores were 6.2 ± 1.9 and 8.5 ± 1.1, respectively. Postoperative back and leg VAS scores were decreased to 3 ± 1.4 (p < 0.05) and 2.7 ± 1.0 (p < 0.05), respectively. Preoperative ODI score was 48 ± 19.1% and postoperative ODI score was decreased to 23 ± 22.1% (p < 0.05). Using Odom’s criteria there were 5 patients (38.5%) with excellent results; 7 cases with good results (53.8%); and one patient with a poor result (7.7%).

Conclusion: Percutaneous hydrodiscectomy could be a good alternative procedure in surgical treatment of lumbar disc degenerative disease. The present series demonstrates promising early clinical results, but more long term follow-up and additional cases are needed to confirm these initial results.

Key Words: Minimally invasive technique • Hydrodiscectomy • Percutaneous • Degenerative disc

INTRODUCTION

The surgical treatment method of lumbar disc disease has evolved since the first report of lumbar discectomy by Mixter and Barr in 1934. Currently, open microdiscectomy is regarded as a gold standard procedure for lumbar disc herniation disease, but many percutaneous procedures have been introduced to treat herniated lumbar disc using minimally invasive technology over the past three decades. The procedures include chemonucleolysis, automated percutaneous lumbar discectomy (APLD), Nucleoplasty®, DeKompressor®, laser discectomy, intradiscal electrothermal therapy (IDET), endoscopic discectomy, etc. Among them, some surgical techniques are still used and others have disappeared as a result of their respective advantages and disadvantages. Recently, the SpineJet® Hydrosurgery System, (HydroCision, Inc., Billerica, MA, USA), using high-pressure fluidjet technology, has been adapted for percutaneous procedures.

MATERIALS AND METHODS

A total of 13 patients who underwent the percutaneous hydrodiscectomy with the SpineJet® Hydrosurgery system from November 2007 to March 2008 at 2 university hospitals and 2 general hospitals, were respectively evaluated. All patients who fulfilled the inclusion criteria and agreed to participate in the signed
an informed consent. The study was reviewed and approved by the Gachon University of Medical and Science’s Institutional Review Board (IRB) (#H-0908-015-041). The mean follow up period was 5.5 months (range: 3.5-8 months). The authors evaluated the clinical results measured by Odom’s criteria, back and leg Visual Analogue Scale (VAS) scores, and Oswestry Disability Index (ODI). Statistical analysis using a two paired t-test was performed with SPSS software for Windows (version 12.0.1; SPSS Inc.). The results were considered statistically significant at a p-value of less than 0.05.

1. Indications

The indications applied for percutaneous hydrodiscectomy were as follows:

1) The leg pain is more severe than low back pain.
2) Radiological findings correspond to the symptoms.
3) Conservative treatment period of more than 3 months
4) Not a sequestered disc fragment
5) No instability in preoperative dynamic roentgenogram
6) Recurrent herniated nucleus pulposus
7) Young and old patients

Also, we excluded patients who have free floating disc fragment, osteophytic impingement on the nerve root, scar tissue entrapped nerve root due to previous surgery, spondylolisthesis and spinal stenosis.

2. Operative procedures

The surgical technique of percutaneous hydrodiscectomy with the SpineJet® Hydrosurgery System is not difficult to perform since the approach is similar to the standard discography technique. First, the patient is positioned in the prone position to visualize the level to be acted on under fluoroscopy. Then, local anesthetics are injected with a 22 G spinal needle. The Access Set guide needle is inserted to the exact level under active fluoroscopic control. The exact position of guide needle is the lateral margin of the ipsilateral pedicle on A-P view and posterior margin of the PLL on lateral view. Then, the guide needle is gradually push into the disc space to the posterior 1/3 portion of the disc space on lateral fluoroscopic view. Then, the dilator is inserted over the needle, and finally the introducer cannula is advanced over the dilator to the correct level. After the removal of the dilator and needle, the SpineJet Micro-Resector® is inserted through the access cannula to remove the protruded disc materials and decompress the nerve root. After the removal of an adequate amount of nucleus pulposus, all of the instruments are removed from the operating site.

While performing the procedure, the surgeon must always reconfirm the exact position of each instrument under continuous fluoroscopic control to penetration the anterior longitudinal ligament which could cause bleeding due to major vessel injury.

RESULTS

The study was consisted of 13 patients; 10 male and 3 female patients with a mean age of 38.1±17.2 years old (range: 20-59). The mean duration of symptoms and conservative treatment period were 18.8±18.3 months and 4.7±1.9 months, respectively. Twelve of 13 patients (92.3%) had low back pain and radiculopathy. One patient presented with back pain only with central protrusion of the disc. All patients had soft disc herniation. Preoperative back and leg VAS score were 6.2±1.9 and 8.5±1.1, respectively. Postoperative back and leg VAS core were decreased 3±1.4 (p<0.05) and 2.7±1.0 (p<0.05), respectively (Fig. 1).

Preoperative ODI score was 48±19.1% and decreased to 23±22.1% (p<0.05) postoperatively. Using Odom’s criteria there were 5 patients (38.5%) with excellent results; 7 cases with good results (53.8%); and one patient with a poor result (7.7%) (Fig. 2).

The patient who had a poor result is 28 year-old man who works as a mechanic in body shop. He had low back pain and radiculopathy for 6 months and his magnetic resonance images showed a left side disc herniation at L4-5 level (Fig. 3). Preoperative symptoms disappeared immediately after the hydrodiscectomy (Fig. 4). However, he returned to his work earlier than recommended, just 2 days after the operation. He complained of radiculopathy again when he came to the outpatient clinic one week after the operation, but he refused to receive further treatment.

The authors gave questionnaires to all of the patients. The patients indicated that they stopped their pain medications in
Fig. 2. The graphs illustrating the Oswestry Disability Index (ODI) Score. The post-operative ODI scores was significantly improved after operation ($p<0.05$).

Fig. 3. Axial T2-weighted image (A) of the lumbar spine at L4-5 level showing the bulging of the disc on the left side. Sagittal T2-weight image (B) showing the compression of dural sac and narrowing of the spinal canal.

Fig. 4. Postoperative axial L-spine CT image at a level of L4-5.

6 cases and reduced to 1/3 dose of medication in 6 cases. They expressed a preference for this operation, if they were to have a herniated nucleus pulposus again in the future. They also would recommend this operation to other patients who have herniated nucleus pulposus.

**DISCUSSION**

There is a debate about whether to perform open microdiscectomy or to do percutaneous procedures when spine surgeons deal with protruded degenerative disc disease. Open microdiscectomy has been generally acknowledged as the standard of care for surgical treatment of herniated lumbar disc disease. While open microdiscectomy has many advantages including high success rates of 88 to 98.5% in various series $^{11,12,17}$, a lot of disadvantages and complications have been reported $^{13,17}$.

In terms of complications, the rate of recurrence has been reported to be from 12 to 26% in the literature. Postoperative epidural fibrosis was observed in between 18 and 37% in a study of 1,500 patients undergoing unilateral single-level open microdiscectomy $^{10}$. Moreover, it is usually performed under general anesthesia which might increase morbidity and mortality, especially in old and medically compromised patients.

The main causes of complication in open microdiscectomy are listed below:

1) Large annulotomy
2) Aggressive nerve root retraction
3) Remove of too much nucleus pulposus

A large annulotomy following laminectomy might increase the rate of recurrence. Nerve injury can be caused by too much retraction during the surgery, and postoperative symptoms such as back pain and radiculopathy can be caused by the decreased intervertebral height resulting from removal of too much nucleus pulposus.

Since in 1983, Kambin and Gellman $^{10}$ introduced the concept of indirect decompression of the spinal canal via a posterolateral approach using a Craig cannula for evacuation of a protruded disc. Many various percutaneous procedures have been developed and performed to minimize such complications and to relieve major symptoms like back pain and radiculopathy for over 30 years. Some percutaneous procedures are still performed, while others have disappeared, due to their respective advantages and disadvantages. The common concept of the percutaneous procedures is to reduce intradiscal pressure by removing nucleus pulposus, which eventually improves the symptoms by reducing the pressure on the nerve root.

In 1975, Hijikata et al. $^{7}$ reported performing a percutaneous nucleotomy under local anesthesia, with partial resection of the disc material via posterolateral approach. They reported the 72% of excellent results in 136 patients had followed-up over the 12-years in 1988. However, this technique did not achieve selective discectomy since the instruments used were straight.
and rigid and could only reach the center of the disc. He pointed out that the diameter of the working cannula was too small (2.6 mm) to allow removal of adequate amounts of nucleus pulposus. These problems were partially eliminated by the instrument by Kambin and his colleagues\textsuperscript{9,10} in 1986 and 1987, comprising working cannulas with diameter of up to 5 mm as well as flexible forceps. However, the working range of these instruments is still limited and does not cover the dorsal part of the intervertebral disc. Onik et al.\textsuperscript{15} reported the development of a blunt-tipped, suction-cutting probe for automated percutaneous discectomy at L4-L5 or higher levels in 1985 and described the 75.2\% of success rate among the 327 patients who met the criteria of the protocol in 1990. Hoppenfeld\textsuperscript{8} reported 43 patients (86\%) had relief of sciatica and sensory deficit. Chatterjee et al.\textsuperscript{3} reported a controlled clinical trials comparing APLD and microdiscectomy in 1994 and concluded APLD is ineffective as a method of treatment of patients with a small contained lumbar disc herniation. Epstein\textsuperscript{6} reported a case of 39-year old woman sustained nerve root and cauda equine injury following a left-sided L5-S1 APLD. Ascher and Heppner\textsuperscript{2}, in Germany, used carbon dioxide and neodymium lasers to treat lumbar disc disease. The largest study documented by Choy et al.\textsuperscript{4} in 1991, the overall success rate with a 26-month period follow up according to MacNab’s criteria was 78.4\% (good and fair). The combined result of Ascher\textsuperscript{1}, Choy et al.\textsuperscript{3}, and others demonstrated 70 to 80\% of long-lasting pain relief for more than 1,000 patients. The only reported complication was one case of discitis in a series of 256 procedures in Ascher’s series after both percutaneous laser discectomy decompression (PLLD) and open surgery, so it is not possible to ascribe this purely to the PLLD. Other possible complications of laser-assisted discectomy can include perforation of aorta, vena cava, iliac vessels, or abdominal organs, and cauda equina syndrome.

Nucleoplasty\textsuperscript{9} was introduced in 2000. Nucleoplasty\textsuperscript{9} uses a unique plasma technology called Coblation to remove tissue from the center of the disc. During the procedure, Nucleoplasty SpineWand which is a 1 mm diameter bipolar instrument creates plasma field at the tip of the device. The plasma field contains sufficient energy to cleave molecular bonds, thereby ablating tissue. The ablation process creates small channels within the disc, removing that portion of tissue. On the withdrawal, bipolar RF coagulation mode is used for additional volume and pressure reduction. However, the disadvantages of this procedure are unable to collect the nucleus pulposus, remove desiccated or large amount of disc material and thermal injury to adjacent tissue.

Dekompressor\textsuperscript{9} is a single-use instrument for removal quantifiable amount of nucleus pulposus through a smallest variable channel allowing discectomy. It is easily performed percutaneous procedure, the methods are like standard lumbar disography. However, it is only applicable to a single-level degenerative disease. The disadvantages are, 1) not indicated to a large disc herniation above 6 mm, 2) only indicated to heal thy nucleus pulposus, not desiccated nucleus pulposus, 3) easily logged by the desiccated disc material during the procedure. Also, the complication of vibratory damage to nerve root was reported.

The problems of percutaneous lumbar discectomy can be summarized as follows: 1) inadequate decompression of disc materials, 2) thermal damage (intradiscal structures can be damaged by heat), 3) low success rate about 50-60\%. To address these problems, percutaneous hydrodiscectomy with the SpineJet\textsuperscript{9} (HydroCision\textsuperscript{9}, Inc., Billerica MA) was introduced.

![Fig. 5. (A) The fluidjet technology (B) Hydrosurgery system including SpineJet and MicroResector.](image-url)
The SpineJet® Hydrosurgery system jets saline fluid with high velocity (900 km/h) to cut, ablate and evacuate the disrupted disc materials safely, quickly and efficiently (Fig. 5, 6). A multi-center study using a cadaver model demonstrated that the SpineJet® XL (similar disposable handpiece with SpineJet® MicroResector) removed nearly 96% more nucleus pulposus from the posterior contralateral region compared to conventional instruments.

The major differences from previous percutaneous procedures are 1) decompression with a removal of adequate amount of disc material by a high-pressure fluidjet 2) no heat damage to intradiscal structures. Other advantages include fast decompression, few morbidities and less blood loss like other percutaneous procedures, and it is easily performed in outpatient clinic under local anesthesia.

CONCLUSION

The authors successfully performed hydrodiscectomy by using the new SpineJet® technology on patients with herniated lumber disc disease, minimizing iatrogenic injury and removing an adequate volume of nucleus pulposus, safely and efficiently in carefully selected patients. Moreover, clinical outcomes were satisfactory due to less postoperative pain and faster return to normal activities.

Percutaneous hydrodiscectomy can be a new alternative procedure in lumber disc decompression. The present series demonstrates promising early clinical results, but more long term data and prospective controlled trials are needed.

REFERENCES