Retrospective Evaluation

Feasibility of Percutaneous Lumbar Discectomy Combined with Percutaneous Cementoplasty for Symptomatic Lumbar Disc Herniation with Modic Type I Endplate Changes

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Background: Treatment of symptomatic lumbar disc herniation with Modic type I endplate changes is complex and challenging, requiring systemic and local therapies which include conservative therapy, epidural infiltrations, percutaneous therapeutic techniques, and surgical options. The clinical management of symptomatic lumbar disc herniation involving Modic type I endplate changes is uniquely challenging because it requires alleviating pain caused by both the herniated disc and the endplate osteochondritis. Through different approaches, percutaneous lumbar discectomy (PLD) and percutaneous cementoplasty (PCP) have been introduced into clinical practice as alternatives to traditional surgical and radiotherapy treatments of symptomatic lumbar disc herniation and other spine diseases.

Objective: To evaluate the feasibility of PLD and PCP for symptomatic lumbar disc herniation with Modic type I endplate changes.

Study Design: PLD and PCP in 7 patients with symptomatic lumbar disc herniation with Modic type I endplate changes and its clinical effects were retrospectively evaluated.

Setting: This study was conducted by an interventional therapy group at a medical center in a major Chinese city.

Methods: Seven consecutive patients (2 men, 5 women; median age, 74.14 ± 5.34 years; age range, 68 – 82 years) who underwent percutaneous lumbar discectomy and cementoplasty for the treatment of symptomatic lumbar disc herniation with Modic type I changes between May 2013 and August 2015 were retrospectively analyzed. The MacNab Criteria, visual analog scale (VAS), and Oswestry Disability Index (ODI) for pain were assessed before and one week, 6 months, and one year after the procedure. Furthermore, the procedure duration, hospital stay length, and complications were assessed.

Results: The VAS of the back and leg decreased from 6.14 ± 0.69 (range, 5 – 7) and 7.29 ± 0.76 (range, 6 – 8) preoperatively to 2.29 ± 1.38 (range, 1 – 5) and 2.71 ± 0.60 (range, 1 – 6) one week, 1.86 ± 0.69 (range, 1 – 3) and 2.00 ± 0.58 (range, 1 – 3) 6 months, and 1.71 ± 0.76 (range, 1 – 3) and 1.85 ± 0.69 (range, 1 – 3) one year postoperatively. The ODI dropped from 76.86 ± 7.45 (range, 70 – 82) preoperatively to 26.29 ± 19.47 (range, 16 – 70) one week, 19.14 ± 2.79 (range, 16 – 24) 6 months, and 18.57 ± 2.99 (range, 16 – 24) one year postoperatively. The mean procedure duration was 55.71 ± 6.07 minutes (range, 50 – 65 minutes). The average length of hospital stay was 7.57 ± 1.27 days (range, 6 – 10 days). No obvious complications were noted.

Limitations: This was a retrospective study with a relatively small sample size.

Conclusion: PLD plus PCP is a feasible technique for symptomatic lumbar disc herniation with Modic type I endplate changes.

Key words: Percutaneous lumbar discectomy, percutaneous cementoplasty, lumbar disc herniation, endplate osteochondritis, Modic type I, feasibility, visual analog scale, Oswestry disability index

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Percutaneous lumbar discectomy (PLD), originally introduced by Hijikata and colleagues is a minimally invasive procedure that preserves the stabilizing elements of the spine and avoids epidural scar formation (1,2). Since its introduction, there have been accumulating studies with promising outcome reports (3-6). This minimally invasive technique has been employed to minimize the manipulation of surrounding tissue, decrease complication rates, and reduce postoperative pain, in addition to improving function (7,8). Furthermore, outcome studies have yet to verify claims that such techniques for lumbar microdiscectomy are better than conventional methods (9,10). However, in cases of lumbar disc herniation with endplate osteochondritis, its use is limited because simple PLD does not address the endplate osteochondritis associated with degenerative lumbar disease (11-14), only making decompression in the nucleus and allowing room for the herniated fragment to implode inward. To overcome these disadvantages, we employed an innovative method—percutaneous cementoplasty (PCP). That is, we used PLD combined with PCP for lumbar disc herniation and endplate osteochondritis with Modic type I endplate changes during a single session. The aim of the present study was to evaluate the feasibility of the combined PLD and PCP method by assessing results from this interventional treatment approach for symptomatic lumbar disc herniation with Modic type I endplate changes.

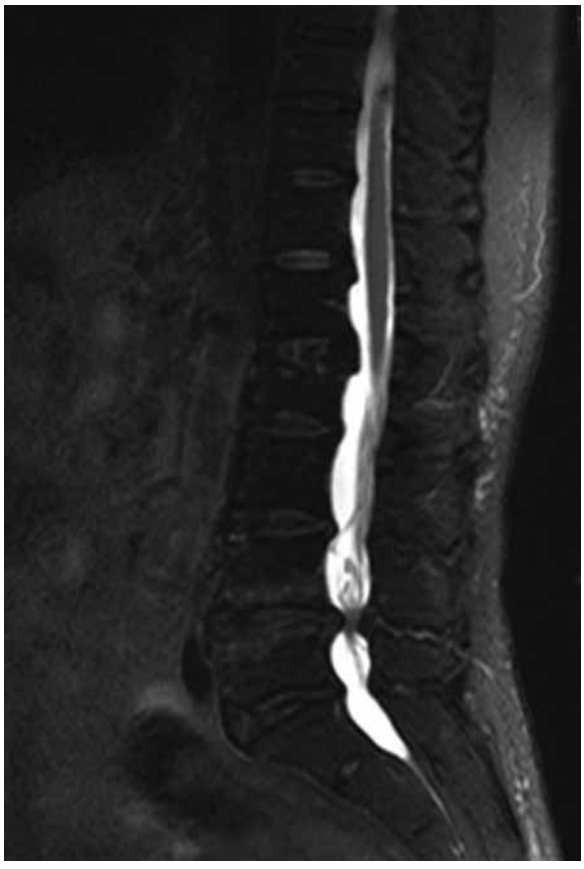

Fig. 1. *Preoperative T2-weighted sagittal MR images of a patient demonstrating L4-L5 disc herniation and Modic type I endplate changes at L4-L5 levels.*

Methods

Patients

This retrospective study was approved by the institutional ethics committee of our hospital, and informed consent was obtained from all patients. From May 2013 to August 2015, patients with symptomatic lumbar disc herniation with endplate osteochondritis showing Modic type I changes were recruited from our department for treatment with PLD and PCP. All patients referred for treatment were asked to complete a short questionnaire about the presence, severity, and duration of pain and disability. Patients were eligible for enrollment if they met the following criteria: (1) neurological signs including radiculopathy, sensory changes, motor weakness, and abnormal reflexes due to a migrated disc with endplate osteochondritis; (2) contained disc protrusion showing Modic type I endplate changes (hypointense signal on T1-weighted images and hyperintense signal on T2-weighted images) in their bone marrow on preoperative magnetic resonance imaging (MRI) of the same level, showing visible narrowing of the disc space (Fig. 1); (3) unsuccessful conservative treatment for at least 6 weeks; (4) age over 60 years at the time of the procedure; and (5) no previous lumbar surgery on the same disc level and reluctance for open surgery. Patients were excluded if any of the following was present: (1) central spinal canal stenosis or lateral recess stenosis, or a narrowed foramen consistent with grade 2 or 3 according to Lee et al (15) and Bartynski and Lin (16); (2) sequestered disc below or above the center of the pedicle of the lower vertebral body; (3) calcification of longitudinal ligaments; (4) coexisting somatic or psychological condition, such as cardiovascular disease, diabetes, infection, spinal tumor, or fracture; (5) untreatable coagulopathy; and (6) allergy to polymethyl methacrylate (PMMA).

PLD and PCP Procedures

The procedures were performed by interventional radiologists under a C-arm x-ray machine. All procedures were performed under local anesthesia with continuous patient feedback; this was of utmost importance to ensure that damage to neural structures was avoided during the procedure. A posterolateral puncture approach was employed with a puncture entry point approximately 8 – 10 cm from the midline of the spinal column in the lateral decubitus position. Under continuous fluoroscopic monitoring, a 14-gauge needle and a guidewire were slowly inserted at the intended site of entry until the tip reached the nucleus cavity of the disc. This was followed by sequential dilation of the tract with the working cannula until the last working cannula (5 mm diameter) reached the annulus fibrosus. After removal of the guidewire and the penultimate cannula, a trepan was inserted through the last working cannula, and the annulus fibrosus was cut anteriorly, followed by removal of herniated disc material with marrow nucleus rongeurs. The discectomy was extended deeper into the involved level so that more herniated disc material could be removed from the disc space. When the discectomy was finished,

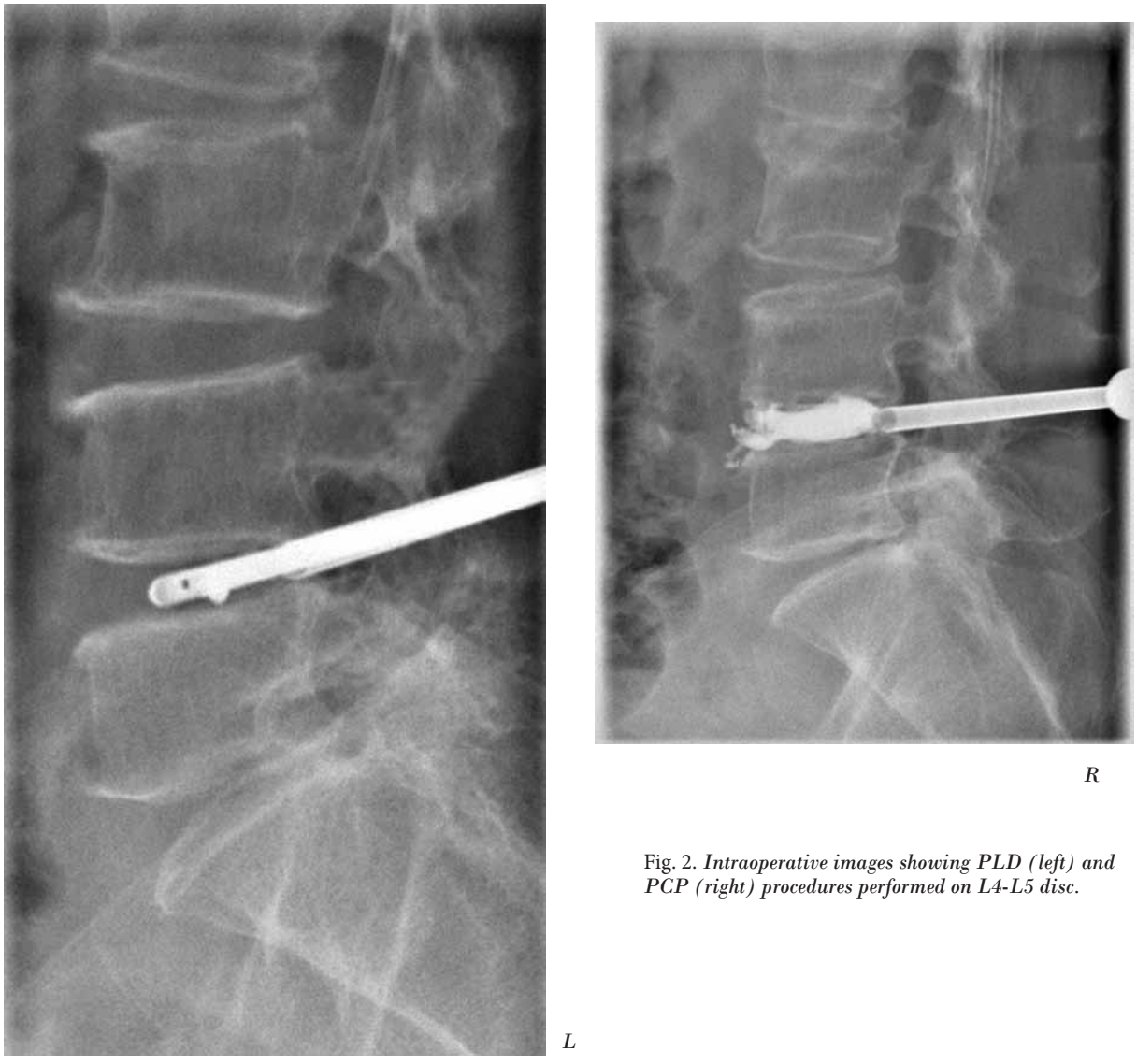

Fig. 2. *Intraoperative images showing PLD (left) and PCP (right) procedures performed on L4-L5 disc.*

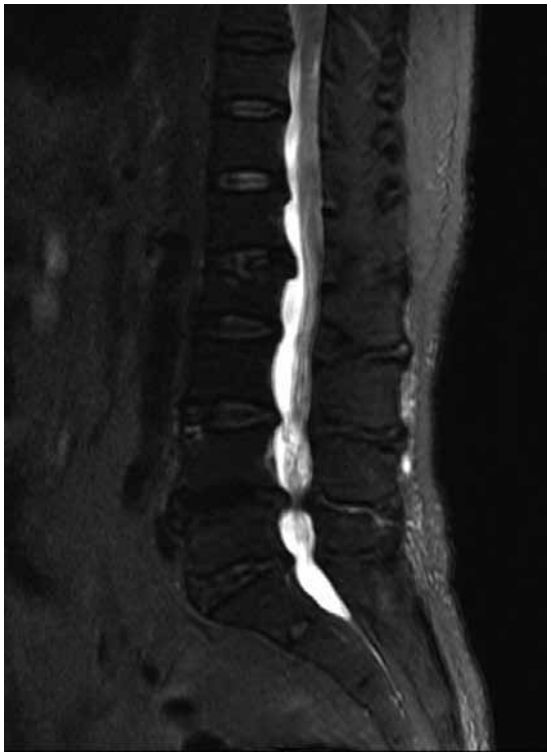

Fig. 3. *Postoperative T2-weighted sagittal MR images of a patient showing good distribution of bone cement in L4-L5 disc.*

suction aspiration and cutting were carried out in a fashion similar to that for automated PLD (3,5) (Fig. 2). Finally, cementoplasty was performed under real-time fluoroscopic guidance. PMMA (Osteo-Firm, COOK, Bloomington, IN, USA) was carefully injected into the disc cavity through the working cannula. Injection was stopped when substantial resistance was met or when the cement reached the cortex edge of the disc. Immediately after the procedure, standard anteroposterior and lateral radiographs were obtained (Fig. 3).

Clinical Outcome Evaluation and Data Collection

Outcomes were assessed according to the MacNab criteria (17), the Oswestry Disability Index (ODI) (18), and the visual analog scale (VAS) for pain (19); these were reviewed and analyzed before as well as one week, 6 months, and one year after the procedures. Also assessed were the procedure duration, length of hospital stay, and complications.

The MacNab criteria defines excellent outcome as no pain and no limitation of normal life; good outcome as occasional pain or paresthesia, but no need of medication and no limitation of normal life; fair outcome as somewhat improved pain but a need for medication, with some limitation of normal life; and poor outcome as no improvement or worsening, and/or a need for additional surgical treatment due to incomplete decompression. The ODI is a 10-item ordinal scale for which each item has 6 possible responses. The score is measured as a percentage (0% – 100%), with an increasing score indicating increasing disability. ODI scores are given as percentages throughout this article. The VAS is a 10-point scale on which patients are asked to rate themselves based on their level of back and/or leg pain, with scores of zero indicating no pain and 10 indicating the worst pain possible. Descriptive data are presented as mean ± SD. All statistical analyses were performed using SPSS version 13.0 software (SPSS, Chicago, IL, USA).

Results

Seven consecutive patients (2 men, 5 women; median age, 74.14 ± 5.34 years; age range, 68 – 82 years) were examined in the present study. The baseline characteristics of the patients and the results are summarized in Table 1. PLD and PCP were technically feasible in all patients, and the mean procedure duration was 55.71 ± 6.07 minutes (range, 50 – 65 minutes). The mean volume of PMMA injected was 3.14 ± 0.69 mL (range, 2 – 4 mL), and mean length of hospital stay was 7.57 ± 1.27 days (range, 6 – 10 days).

According to the MacNab criteria, 3 patients (42.86%) had excellent results, 3 (42.86%) had good results, and one (14.18%) had fair or poor results. Preoperatively, the back and leg VAS scores were 6.14 ± 0.69 (range, 5 – 7) and 7.29 ± 0.76 (range, 6 – 8), respectively. After surgery, the VAS scores for the back and leg decreased significantly to 2.29 ± 1.38 (range, 1 – 5) and 2.71 ± 0.60 (range, 1 – 6) one week after the procedure, 1.86 ± 0.69 (range, 1 – 3) and 2.00 ± 0.58 (range, 1 – 3) 6 months after the procedure, and 1.71 ± 0.76 (range, 1 – 3) and 1.85 ± 0.69 (range, 1 – 3) one year after the procedure, respectively. Furthermore, the ODI dropped from 76.86 ± 7.45 (range, 70 – 82) preoperation to 26.29 ± 19.47 (range, 16 – 70) one week postoperation, 19.14 ± 2.79 (range, 16 – 24) 6 months postoperation, and 18.57 ± 2.99 (range, 16 – 24) one year postoperation (Table 1). No occurrences of surrounding tissue damage were seen (no nerve damage or spinal damage), and there were

Table 1. *Clinical outcomes of VAS and ODI pre-operation and post operation.*

Patients	Gender	Age	VAS (back)				VAS (leg)				ODI			
			Pre	1w	6m	1y	Pre	1w	6m	1y	Pre	1w	6m	1y
1	F	70	7	3	2	3	8	3	2	3	82	20	20	24
2	M	75	6	2	2	2	7	2	2	2	76	18	16	16
3	F	68	6	2	2	2	7	3	2	2	80	24	20	18
4	F	82	6	1	2	1	8	2	2	2	80	20	20	20
5	F	79	5	1	1	1	6	1	1	1	72	16	16	16
6	M	69	6	2	1	1	7	2	2	1	70	16	18	16
7	F	76	7	5	3	2	8	6	3	2	78	70	24	20

VAS = visual analog scale; ODI = Oswestry Disability Index.

no other complications such as bacterial infections, anesthesia-related adverse events, and/or bleeding. PMMA leakage into the puncture path was observed in one patient during the operation under real-time fluoroscopic guidance. The patient complained of slight low back pain on the operation side after the procedure that resolved within 24 hours without special treatment.

Discussion

Chronic lower back pain is one of the most frequent health problems in modern societies that occurs with age (20). Approximately 80% of the population in Western countries have experienced at least one episode of lower back pain in their lifetime, and 55% have experienced lower back pain associated with radicular symptoms (21). The spine is a major source of pain and disability (22). Many studies have reported that lumbar muscles, intervertebral discs, nerve roots, and facet joints are a source of low back pain (23,24). The lumbar disc, because of its highly specialized role and relatively susceptible nature, is one of the major sources of lower back pain syndrome. Inversely, probably because of reduced strenuous activity combined with decreased hydration and fibrocartilaginous metaplasia of the nucleus pulposus, it is spinal stenosis rather than herniated lumbar discs that most frequently affects the elderly (25). However, as the number of elderly people steadily increases, lumbar disc herniation has become more common in the elderly, which comprise about 5% of the patients who undergo lumbar discectomy worldwide (26).

The therapeutic armamentarium for symptomatic intervertebral disc herniation includes conservative therapy, epidural infiltrations, percutaneous therapeutic techniques, and surgical options. The prognosis of low back pain and sciatica in the acute setting is often favorable, with the majority of patients responding well to conservative treatment regimens of physiotherapy, nonsteroidal anti-inflammatory drugs, and oral analgesia. However, approximately 10% of such patients and even more patients with chronic low back pain require further intervention, and it is this cohort of patients which present a therapeutic dilemma (27,28). For most symptomatic patients with demonstrable disc herniation, surgical intervention will provide faster pain relief and return to activities than conservative treatment. Surgery can produce satisfactory results in a high proportion of patients in the short- to medium-term. These therapeutic principles are as valid for elderly patients as they are for the younger age groups, and some studies have demonstrated that discectomy is highly effective for older patients with long-term successful pain relief (26,29). However, it is also known that surgical discectomy can cause mechanical disruption to adjacent vertebral levels, leading to increased risk of degenerative change over time in these locations (30,31). In addition, lumbar discectomy is an expensive, invasive surgical procedure that carries a complication rate of at least 3% including discitis and neurological disability (32). Due to the limitations of surgical discectomy in this patient cohort, there has been much focus upon minimally invasive treatment options for symptomatic lumbar disc herniation, which can be classified into 4 main categories: mechanical, thermal, chemical decompression, and biomaterial implantation.

PLD was first described by Hijikata et al in 1975 (1). It was modified to automated PLD by Onik et al (2), which aims to reduce mechanical nerve root compression by aspirating a volume of the nucleus pulposus of the herniated lumbar disc using a percutaneously placed suction cutting probe. In properly selected patients with contained lumbar disc herniation, percutaneous lumbar discectomy has been reported to decrease operative

trauma by reducing incision size, thereby reducing postoperative pain, hospital stay, and time off work, while improving clinical outcome (33,34). It is reported that PLD can be used either as an initial treatment or as an attractive alternative prior to surgery for the therapy of symptomatic herniation in both the cervical and lumbar spine. Eloqayli and Al-omari (35) even suggested that in the absence of objective evidence of spinal instability, recurrent disc herniation with predominant leg pain may be treated by automated percutaneous lumbar discectomy (APLD) as a first-line option.

Recently, endplate osteochondritis with Modic changes has been a new topic of interest in the current spine literature because of its suggested strong link with a specific cause of discogenic low back pain (36-38). A study by Albert and Manniche (36) showed that the prevalence of Modic type I changes increased from 9% at baseline to 29% during the follow-up in patients with low back pain, indicating a strong association between Modic changes (especially type I) and nonspecific low back pain. Moreover, 2 recent studies have also found a positive relationship between the presence of endplate osteochondritis with Modic changes and disc herniation at the same spinal level in both the lumbar and cervical regions (39-40). More importantly, it has been reported that patients with symptomatic lumbar disc herniation and endplate osteochondritis with Modic changes had significantly lower levels of pain reduction after minimally invasive surgeries compared with those without endplate osteochondritis showing Modic changes (41-43). Interestingly, Modic changes have also been found in cases in which disc procedures were not successful. Furthermore, Masala et al (44) has demonstrated that vertebroplasty with bioactive resorbable bone cement may be an effective therapeutic option for patients with low back pain resistant to conservative treatment whose origin might be Modic type I endplate degenerative changes. All this prompted us to design a new approach to treat this cohort of patients.

The technique described here, being minimally invasive, has a great advantage for the elderly patient with Modic type I changes who is not a candidate for traditional treatments. To our knowledge, the present study is the first to report the use of PLD and PCP for elderly patients with Modic type I changes. In this study, all the patients had immediate pain relief and significantly improved daily life. Since the cushioning effect of the lumbar disc is not as important as stabilization due to decreased bouncing activities in the elderly, we can inject bone cement into the lumbar disc. The combination method described here focuses on 3 equally important points: decompression, stabilization, and anti-inflammation. PLD can directly remove the herniated disc within the protrusion and the nucleus pulposus, consequently, decreasing outer annular inflammation and pressure. However, removal of the nucleus pulposus inevitably lowers the intervertebral disc, thus increasing spinal instability and pressure on the nerve roots. Meanwhile, injection of bone cement into the lumbar disc can effectively diminish inflammation and support stabilization as well as restore the intervertebral space height. The increase in intervertebral height also indicates decompression of the spinal canal pressure. In this study, PLD plus PCP was used for all 7 study patients and achieved these goals.

In the present study, the procedure was found to be successful and highly feasible. PLD plus PCP is a minimally invasive procedure which may be useful for elderly patients with lumbar disc herniation and Modic type I changes—particularly for those in poor general health—and has several advantages over conventional treatments. First, blood loss and trauma associated with this procedure are generally negligible, with a low risk for infection or damage to the surrounding muscles. Second, it can be performed under conscious sedation with minimal pain. Third, the short period of bed rest required and short hospital stay decrease the risk of thromboembolic complications compared with conventional surgery. Last, but not least, this treatment can be performed in combination with other treatments, such as intradiscal electrothermal annuloplasty or percutaneous laser disc decompression.

There are certain limitations to the present study, including its small sample size and relatively short follow-up interval. Moreover, there is no comparison with other therapeutic options such as PLD alone or the lack of any other treatment. In addition, because of the relatively high rate of concurrent spinal stenosis and disc herniation in older patients, the target population described here would be a very small percentage of the total number of patients seen. Furthermore, a bioactive material may make more sense to use rather than PMMA because of its monomer toxicity, higher setting temperature, and higher stiffness; PMMA was used here because it was readily available.

Conclusion

In conclusion, PLD plus PCP as an optional treatment for elderly patients with lumbar disc herniation and Modic type I endplate changes is highly feasible for

interventional radiologists. Moreover, it appears to be a promising alternative for patients who are reluctant or not candidates for surgery due to poor general health. In addition, it is a minimally invasive technique that can be performed under conscious sedation, with very low complication rates and a short hospital stay. However, further studies with larger sample sizes and with comparisons with other available treatments are required to confirm these preliminary findings.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

Statement of human and animal rights

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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