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SCIENTIFIC ARTICLE

CT- and fluoroscopy-guided percutaneous discectomy for lumbar radiculopathy related to disc herniation: a comparative prospective study comparing lateral to medial herniated discs

Nicolas Amoretti · Laurent Huwart · Pierre-Yves Marcy · Pauline Foti · Olivier Hauger · Pascal Boileau

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Abstract
Objective To evaluate and compare two groups of patients with sciatica due to intervertebral disc herniation with no neurologic deficit. The groups consisted of patients with intervertebral disc herniation in a medial location (group 1) and those in a lateral location (group 2).
Materials and methods A total of 200 patients were included in the study and were followed for a minimum of 6 months. In our series, we treated 80 postero-lateral herniated discs (40% of cases), 46 postero-medial herniated discs (23%), and 74 foraminal herniated discs (37%). Level L3-L4 was treated in 30 cases (15%), L4-L5 in 98 cases (49%), and L5-S1 in 72 cases (36%). The procedure was performed under dual guidance: fluoroscopic and CT. A helical probe was activated. It penetrates the herniated disc and causes the pulpous material to be mechanically evacuated through the probe. All 200 patients were followed for a minimum of 6 months.
Results In group 1, the patients had a mean pain score of 7.9± 2.5 VAS units (range 6–10 units) prior to intervention. This was reduced to 3.2±2.1 VAS units (range 0–10 units) at 48 h follow-up and increased to 3.9±1.2 VAS units (range 0–10 VAS units) at 1 month follow-up and further reduced to 2.7± 1.2 units (range 0–10 VAS units) at 6 month follow-up. In group 2, the patients had a mean pain score of 8.2±3.2 VAS units (range 6–10 units) prior to intervention. This was reduced to 2.8±1.5 VAS units (range 0–10 units) at 48 h follow-up and decreased to 1.5±0.9 VAS units (range 0–10 units) at 1 month and further reduced to 1.1±0.5 VAS units (range 0–10 units) at 6 months.
Conclusion Our study showed that results were more satisfactory for the hernia located laterally (postero-lateral, foraminal, and extra-foraminal) as compared to the hernia located posteromedially.

Keywords Percutaneous disk decompression · CT guidance · Spine · Interventional radiology

N. Amoretti (✉) · L. Huwart · P.-Y. Marcy
Department of Radiology, Hôpital archet 2,
Centre Hospital-Universitaire de Nice,
151, route de saint antoine de Ginestière,
06200 Nice, France
e-mail: amorettinicolas@yahoo.fr

P. Boileau
Department of Orthopedic Surgery, Hôpital archet 2,
Centre Hospital-Universitaire de Nice,
Nice, France

P. Foti
Department of Medical Statistics, Hôpital archet 2,
Centre Hospital-Universitaire de Nice,
Nice, France

O. Hauger
Department of Radiology, Hôpital Pellegrin,
Centre Hospitalo-Universitaire de Bordeaux,
Bordeaux, France

Introduction

Lower back pain related to disc herniation is one of the leading causes of morbidity in industrialized nations [1]. The recommended treatment plan comprises, as a first step, conservative treatment for 2–6 months, including medical treatment with anti-inflammatory drugs, analgesics, rest, and physical therapy. In case of treatment failure, or as a second

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step, the only recommended alternative for treating this type of pain is surgical discectomy. As with any surgery, there are risks related to its invasive nature: infection, treatment failure, relapse, or postoperative fibrosis [2, 3]. Thanks to progress in interventional imaging, new techniques have been developed that overcome the lack of therapeutic options intermediate between the medical and the surgical treatment. Percutaneous discectomy is a minimally invasive, highly effective treatment for back and neck pain caused by herniated and bulging discs [1]. It is designed to alleviate pressure on a compressed nerve by directly excising the disc that is pushing against the nerve root [2]. Decompression of the nerve root helps to restore functionality and relieve pain [3].

The objective of this study conducted on 200 patients was to compare and demonstrate that CT-guided percutaneous discectomy for herniated discs results in a significant improvement in pain symptoms at several time points (1 day, 2 days, 1 month, 6 months). This objective assesses the effectiveness and feasibility of this technique under CT guidance in patients presenting with documented lower back pain related to disc herniation that had not improved under appropriate medical treatment.

Materials and methods

This pilot study was conducted in our university teaching hospital from January 2010 to January 2011. Inclusion and exclusion criteria are presented in Table 1.

All patients were informed about the study, the technique, and the benefits and risks associated with it. A written consent was obtained. This study was approved by both the university ethics panel and the review board of our institution. National legislation and the principles of the Declaration of Helsinki were followed. No industry support was received for this study. This information included the possibility of recurrence of radicular symptoms during the injection and/or transient exacerbation after the treatment. The treatment took place after patients had given informed consent to participate in the study.

This study did not involve a control group. The indications for our series were approximately superimposed on those of a series involving traditional discectomy. We prospectively studied and compared two groups of patients with sciatica due to intervertebral disc herniation with no neurologic deficit. The patients were divided into two groups: those with intervertebral disc herniation in a medial location (group 1) and those in a lateral location (group 2). A total of 200 patients were included in the study and were followed for a minimum of 6 months. In our series, we treated 80 postero-lateral herniated discs (40% of cases), 46 postero-medial herniated discs (23%), and 74 foraminal herniated discs (37%). Level L3–L4 was treated in 30 cases (15%), L4–L5 in 98 cases (49%), and L5–S1 in 72 cases (36%) (Figs. 1 and 2).

The diagnosis of lumbar radiculopathy was established by both the referring physician and interventional radiologist, in accordance with history and physical examination findings. The root level involved was determined from the location of the radiating pain, the distribution of paresthesia or motor weakness, or a combination of both. In each patient, radiographs of the lumbar spine had initially been

Table 1 Inclusion and exclusion criteria for patient selection

Inclusion criteria	Exclusion criteria
Male or female	Disc compression with significant dehydration (disappearance of hyperintense signal on T2)
More than 18 years old	Estimated motor deficit≤3/5
Lower back pain with a herniated disc confirmed by MRI	Neurological deficit (hypo anesthesia or perianal anesthesia, sphincter disorders)
Failure of appropriate conservative medical treatment including analgesics, NSAIDs, or corticosteroids in case of contraindications of the former	Hemostasis disorders (PT less than 70, APTT greater than 40, platelets less than 150,000)
At least one infusion including the possibility of a foraminal infusion under CT guidance, and physical therapy	Anticoagulant treatment (aspirin, AVK)
VAS of pain greater than or equal to 6/10	Current infection
Radiculalgia consistent with the location of the herniated disc documented by MRI	Lower back pain of etiology other than a herniated disc
Degree of hydration of the conserved disc (persistence of a hyperintense signal on T2 TSE)	Spondylolisthesis greater than one-third
Patient not under guardianship or trusteeship	Previous back surgery
	Infusion performed within the past 10 days
	Pregnancy

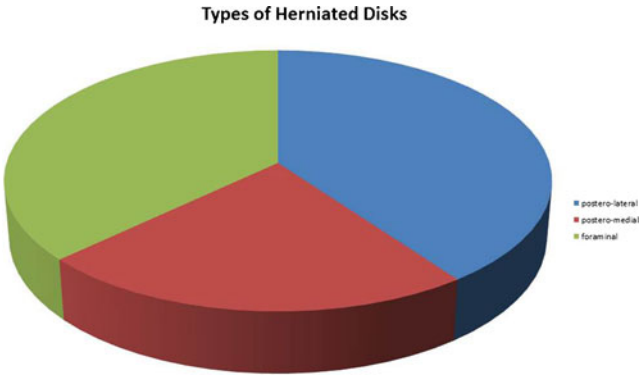

Fig. 1 Herniated disk levels

obtained and a magnetic resonance imaging (MRI) examination had been performed to determine the causal lesions and to exclude an anatomic variant, especially for vascular and bone structures. The case report form collected the following information: age, indication, location and level of the herniated disc, and pain evaluation (Table 1).

Pain was evaluated using the Huskisson visual analog scale (VAS) (VAS: 0=absence of pain, 10=worst possible pain) graduated in centimeters.

Patient follow-up was carried out by consultations at day 2, 1 month, and 6 months. Patient follow-up was carried out by both the referring physician and interventional radiologist. We used the classification of complications recognized by the Society of Cardiovascular and Interventional Radiology (SCVIR). Minor complications are those not requiring any treatment or requiring a minimal treatment without consequences. Major complications are those requiring significant specific care, an increase in the level of care, and/or an extension of the duration of hospitalization greater than 48 h.

The technique used in our department combines CT and fluoroscopic guidance (C-arm General Electric Stenoscop) for a better visualization in the sagittal plane of the disc and for carrying out discography, and uses CT (General Electric Lightspeed 8 slice detector, Kalamazoo, MI, USA) for location in the axial plane. It also enables the visualization of

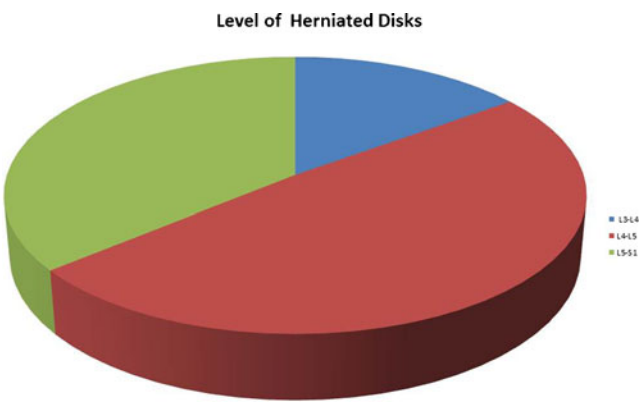

Fig. 2 Types of herniated disks

the herniated disc or disc protrusion to allow a better trajectory in the positioning of the equipment used in the discectomy techniques for herniated discs. The procedure is carried out in the interventional CT room. The procedure was performed under dual guidance with fluoroscopy and CT by a well-trained physician (12 years of experience) and under strictly aseptic conditions.

First, a CT scan is performed: information on the volume of the disc and nerve root lesion is gathered with 1 mm slices reconstructed every millimeter. A scan of the approach path is then measured as a function of the herniated site. In case of foraminal or extra-foraminal herniated disc, a postero-lateral approach is used (Fig. 3). A juxtadural postero-lateral approach is performed for postero-medial or postero-lateral herniated discs (Fig. 4).

Then, a CT-guided discography is performed under local anesthesia according to the path and angle determined by the first CT scan. This will allow a trans-herniated disc approach.

The test discography confirms the diagnosis of disc and nerve root lesion at the appropriate level. The opacification facilitates the optimal positioning of the distal tip of the probe in the herniated disc. The trocar used to introduce the probe is curved to allow a larger extraction area and facilitate the passage of the herniated disc in case of difficult access (Herniatome, Gallini Srl. Medical Devices, Mantova, Italy). To start, a helical probe is activated. It penetrates the herniated disc and causes the pulpous material to be mechanically evacuated through the probe (Fig. 5). The procedure is complete when successive rotational movements do not remove any further pulpous material (Fig. 6). The entire procedure, including patient positioning, lasts about 15 min. No sutures are necessary. The patient is hospitalized for 48 h of surveillance in the rheumatology department. Anti-inflammatory medication may be prescribed for a period of 3 days after the procedure.

Statistical analysis

Analysis of variance of the results was carried out by using the Levene test; statistical significance was analyzed with

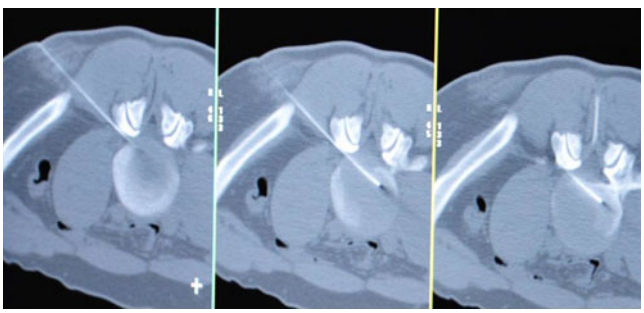

Fig. 3 In case of foraminal or extra-foraminal herniated disc, a postero-lateral approach is used. Here an axial CT scan confirms the correct positioning of the needle

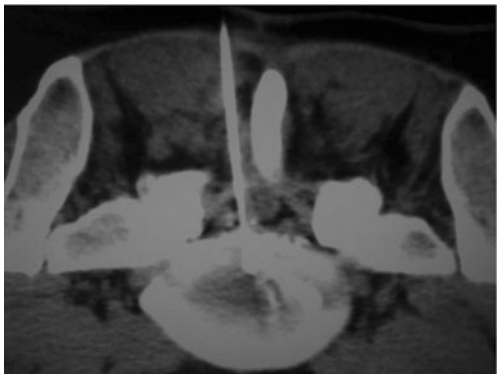

Fig. 4 A juxtadural postero-lateral approach is used for postero-medial or postero-lateral herniated discs

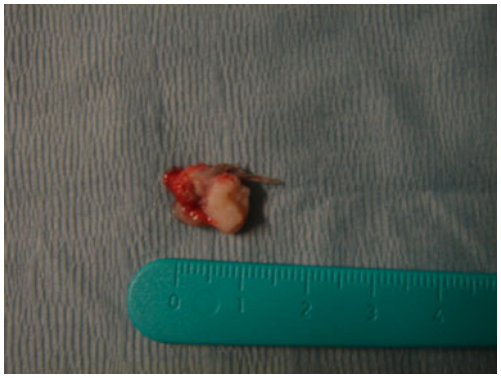

Fig. 6 Visualization of an extracted nucleus sample at the end of a procedure allows for a quantitative and qualitative judgment of the decompression

the Pillai-Spur, Wilk's-Lambda, Hotelling-Spur and Scheffe multivariable tests.

The statistical significance hypothesis was accepted for $p<0.05$.

The numbers and percentages are qualitative values. The average, median, and standard deviation are quantitative values. The only primary variable is spinal nerve root pain evaluated on the VAS scale. An analysis of absolute values was performed to judge the variation in VAS over time. We calculated the differences in VAS for each patient at different times T as compared to the initial VAS value and performed an analysis on the relative differences. The Levene tests demonstrate that the data can be analyzed for statistical significance with a significance threshold starting at 5%. We tested these differences as compared to the null hypothesis by means of a Wilcoxon signed ranks test. SPSS 7-0 was used to perform statistical analysis.

Results

Group 1 (medial location of the herniated disc) included 46 patients (26 men, mean ± standard deviation age, 43±4.9 years ; 20 women, age 42±6.1 years). Group 2 (lateral location of the herniated disc) included 154 patients (90 men, age 47±5.2 years; 64 women, age 40±5.0 years). All 200 patients were followed for a minimum of 6 months.

Fig. 5 A helical probe is activated. It penetrates the herniated disc and causes the pulpous material to be mechanically evacuated through the probe

In group 1, the patients had a mean pain score of 7.9±2.5 VAS units (range 6–10 units) prior to intervention. This was reduced to 3.2±2.1 VAS units (range 0–10 units) at a 48 h follow-up, increased to 3.9±1.2 VAS units (range 0–10 VAS units) at 1 month follow up, and was further reduced to 2.7±1.2 units (range 0–10 VAS units) at 6 month follow-up. On a percentage basis, mean pain reduction in group 1 was 65% within a 6 month follow-up period. In one case, a complication involving staphylococcal epiduritis occurred and resulted in premature surgery (laminectomy) and antibiotherapy without sequellae.

In group 2, the patients had a mean pain score of 8.2±3.2 VAS units (range 6–10 units) prior to intervention. This was reduced to 2.8±1.5 VAS units (range 0–10 units) at a 48 h follow-up, decreased to 1.5±0.9 VAS units (range 0–10 units) at 1 month, and was further reduced to 1.1±0.5 VAS units (range 0–10 units) at 6 months. On a percentage basis, mean pain reduction in group 2 was 81% within a 6 month follow-up period.

By using the Wilcoxon test or the ranked sign test with a threshold of 0.05, highly significant results were obtained ($p=0.0001$) at all times T. There was a significant improvement in pain at different times (T=48 h, T=1 month, and T=6 months) as compared to pre-intervention pain. The Wilcoxon test demonstrated significant values for all times and also tested the change in absolute value as compared to the initial value. The Levene test demonstrated that four of the six VAS evaluation times presented a significant difference in variance. The difference in the level of VAS reduction was statistically significant with $p=0.006$ with a coefficient of variation of 15.5%. This reduction thus achieves a level of significance of less than 1%.

Discussion

The current standard treatment for lumbosacral neuralgia resistant to appropriate conservative medical treatment is surgical discectomy of which the goal is the extraction of fragments of the herniated disc and decompression of the nerve root. This is nevertheless a serious operation with a non-negligible rate of complications due to its invasive nature. It also is associated with a hospital stay and significant public health costs. Percutaneous fine needle discectomy with the Herniatome® probe under combined CT and fluoroscopic guidance is a minimally invasive spine surgery which should be considered as an alternative.

This technique presents several advantages: The small diameter of the probe used (maximum 16 G or 1.5 mm) allows a cutaneous incision of only a few millimeters, and a trans-canal approach is possible. It also decreases the risk of ligament lesion and does not cause an osseous injury of the posterior arc or damage to the adjacent muscular structures. The curved probe and the lateral windows permit a wider extraction of the hernia. Previous series also demonstrated an absence of postoperative fibrosis or subsequent exacerbation of disc degeneration [4, 5].

CT and fluoroscopic guidance during the procedure results in optimal probe positioning: the decompression probe and the trocar for insertion of the probe are curved for more complex approaches, which also enables extraction motions of larger amplitude. The rotating probe system allows the nucleus to be extracted by suction at the medial as well as postero-medial or (extra-) foraminal levels. No technical failure was reported. Visualization of an extracted nucleus sample at the end of the procedure allows for a quantitative and qualitative judgment of the decompression to be made and demonstrates the absence of associated tissue lesions [4]. Finally, this method has the advantage of not complicating subsequent surgical procedures in case of failure. The hospital stay is short (average of 24 h in the Rheumatology Department), and the return to activity is rapid. Several studies support the efficacy of percutaneous discectomy. Notable recent studies include a comparative prospective randomized study comparing conservative treatment and percutaneous disc decompression for treatment of vertebral disc herniation [5]. The study reported the relative long-term benefit of percutaneous disc decompression over conservative therapy, and when compared with conservative therapy, percutaneous disc decompression shows improved amelioration of symptoms at 12 and 24 month follow-up. A clinical trial published in 2011 reported a decrease in pain as measured by lowered average analog score of up to 71% in patients treated for herniated discs at 1 week and 79% at six months [6]. The particularity of our study is that results were more satisfactory for the hernias located laterally (postero-lateral, foraminal, and extra-foraminal) as compared to the hernias located posteromedially ($p<0.01$).

Surgical discectomy achieves the best results when the herniated discs are medial and paramedial, but the extra-foraminal herniated discs are at the limit of the surgical indication. This particularly difficult approach, which is associated with technical difficulties, may indicate our procedure as an alternative to discectomy for this type of herniated disc.

Conclusion

Our study involved 200 cases in which a minimum of 6 weeks of conservative treatment was given, although the appropriate duration of conservative treatment remains an open question, with some authors discussing a period of 6 months. The results obtained with percutaneous discectomy using the Herniatome® probe under CT and fluoroscopy guidance are safe and effective. Our work showed that results were more satisfactory for hernias located laterally (postero-lateral, foraminal, and extra-foraminal) as compared to hernias located posteromedially. Percutaneous fine needle discectomy with the Herniatome® probe under combined CT and fluoroscopic guidance is a minimally invasive spine procedure which should be considered as an alternative to surgery. The minimally invasive nature of percutaneous discectomy provides compelling advantages over more invasive procedures such as open surgery. It permits herniated discs to be excised with minimal disturbance to surrounding skin, fascia, and muscles, which promotes quicker recovery and lower risk of complications than more invasive treatments. It also allows the procedure to be performed in an outpatient setting.

Conflict of interest None of the authors received or receives commercial support or is financially involved with the device used in this study.

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