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MUSCULOSKELETAL RADIOLOGY

Percutaneous cervical discectomy: retrospective comparison of two different techniques

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Abstract

Aim To compare clinical success and patient satisfaction of percutaneous cervical nucleoplasty (PCN) and percutaneous cervical discectomy (PCD) in contained cervical disc herniation treatment.

Materials and methods We retrospectively identified 50 consecutive patients in our institution: 24 underwent the PCD treatment and 26 patients were treated by the PCN procedure. All patients complained of radicular pain with or without neck pain; diagnosis of contained cervical disc herniation was obtained by MRI; all patients had received conservative therapy which did not result in symptom improvement. Exclusion from our series consisted of patients who had undergone previous surgery at the indicated level, or those with myelopathy, or those in whom more than a sole herniation was treated in the same session. Overall procedure time, fluoroscopy time, radiation dose and complications were recorded. The MacNab scale score was used to assess clinical success in terms of pain relief at 2- and 6-month follow-up. After 4–6 months, a cervical MRI was obtained in 24 patients.

Results Neither major nor minor complications were reported. Regarding patient satisfaction, overall median modified MacNab score was excellent both at 2 and 6 months after treatment. No significant statistical difference was found in mean modified MacNab score at 2 and 6 months among patients grouped by treatment choice ($p = 0.319$ and 0.847, respectively); radiation dose was inferior in PCN group than in PCD, with no significant statistical difference.

Conclusion PCD and PCN were found to be safe and effective in terms of pain relief in contained cervical herniation treatment.

Keywords Cervical disk herniation · Nucleoplasty · Discectomy · Percutaneous

Introduction

Cervical radiculopathy is a common clinical entity which may represent a debilitating disease and cause patients significant impairment. Indeed, pain originating from intervertebral disc pathology is difficult to manage and is costly to healthcare organizations in Western countries [1].

In these patients, pain syndromes and deficits may arise as a combination of both ischaemia and inflammation and may be related to the mechanical compression of the nerve root

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by the portion of the extruded disc, accompanying inflammatory response and released chemical mediators [2, 3].

When conservative treatment fails and symptoms persist or worsen, surgical treatment is considered. Open surgery for cervical disc herniation is a well-established and successful procedure, in spite of the obvious drawbacks of almost any surgical intervention. In recent years, the trend towards minimally invasive spine surgery is the result of a diverse combination of factors including the aim to reduce perioperative complications and post-operative recovery time, the development and refinement of new technologies and patient awareness of emerging therapeutic approaches [4].

A discrete number of minimally invasive methods for treating cervical hernias through devices inserted percutaneously into the intervertebral space and subsequent disc decompression has been developed, most commonly involving mechanical or energy-based removal of some portion of the nucleus pulposus, used in the therapy of small-to-medium-sized hernias of intervertebral discs [5]. Indeed, percutaneous removal of nuclear material could relieve patient symptoms, based on the principle that a small reduction in volume in a closed hydraulic space (e.g. an intact disc) causes a disproportionately large decline in pressure [6]; this theoretically creates space for the herniated fragment to implode, which, in turn, mitigates some chemical and mechanical factors involved in pain pathogenesis.

Percutaneous cervical discectomy (PCD) has proved to be an effective treatment option for soft cervical disc herniation [7]; the procedure generally consists in cutting out and removing the disc herniation by suction, which reduces the pressure and volume in the disc.

Conversely, percutaneous cervical nucleoplasty (PCN) is another successful minimally invasive technique [4, 6, 8] based on coblation technology which uses radiofrequency energy to ablate the nucleus pulposus in a controlled manner in order to obtain disc decompression, resulting in minimal damage to surrounding healthy tissue [8].

Until today, one study has previously compared clinical success with PCN and PCD in the treatment of cervical disc herniation [2].

Nevertheless, patient satisfaction and the assessment of the results by magnetic resonance imaging (MRI) with the two treatments are lacking.

The aim of the present study was to investigate and compare results of PCN and PCD, including patient satisfaction, in contained cervical disc herniation.

Materials and methods

This single-centre retrospective study was approved by the institutional review board, and informed consent was given by all patients.

Patients

From July 2016 to July 2018, we extrapolated a total of 50 consecutive patients among our patients who had undergone percutaneous minimally invasive treatment for cervical herniation.

Twenty-four patients (15 men and 9 women; average age 44.3 years, range 35–55 years) underwent the PCD treatment (Group A).

Instead, Group B included 26 patients (14 men and 12 women; average age 48.5, range 30–55 years) treated with the PCN procedure.

The characteristics of this retrospective study cohort are summarized in Table 1.

Patients included in this research had to satisfy specific inclusion and exclusion criteria to be enrolled. Notably, all patients complained of radicular pain with or without neck pain and were diagnosed with contained cervical disc herniation by MRI. In each case, indications and contraindications to the procedure were evaluated on the basis of the CIRSE guidelines [9].

Before the intervention, all patients received conservative therapy (including physical therapy combined with anti-inflammatory drugs and muscle relaxants at the manufacturer's recommended therapeutic dose for no less than 6–8 weeks), which did not result in symptom improvement.

Absolute contraindications were: sequestered disc fragment; spondylolisthesis; stenosis of the spinal canal; asymptomatic intervertebral disc bulging incidentally discovered at computed tomography or MR imaging; untreated, ongoing active infection and/or discitis; and pregnancy.

Relative contraindications were as follows: coagulopathy (to be corrected before the procedure); anticoagulant therapy (to be interrupted before the operation); and severe degenerative disc pathology (more than two-thirds in disc height decrease).

Table 1 Details of the patient characteristics of each treatment group

	Percutaneous discectomy (Group A)	Percutaneous nucleoplasty (Group B)
Total of patients	24	26
Males	15	14
Females	9	12
Level of disc herniation		
C3–C4	5	6
C4–C5	6	6
C5–C6	7	8
C6–C7	6	6

Patients who had undergone previous surgery at the indicated level, or those with myelopathy, or those in whom more than a sole herniation was treated in the same session were excluded from our series.

Procedure and post-operative evaluation

All the procedures were performed in our angiographic suite (GE-Innova 2100-IQ, GE Healthcare, USA) by two interventional radiologists with more than 10 years of experience in percutaneous techniques. In each case, the operator has chosen the technique employed on the basis of his confidence with the procedure.

The patient was placed in a supine position with the neck slightly extended; the shoulders were gently held in a downward position with tape or a soft strap. Local anaesthesia at the needle entrance site was achieved with subcutaneous injection of a 10-ml solution of lidocaine, to monitor any changes in symptoms.

Firm pressure was digitally applied to the space between the right sternocleidomastoid muscle and the trachea and directed towards the targeted intervertebral disc space. The operator was able to feel the beats of the carotid artery with his or her fingers. The trachea was then displaced medially, while the carotid artery was displaced laterally: as a consequence, the operator was able to slip his/her fingers towards the front of the vertebral body.

C-arm fluoroscopy was used in the lateral plane for the placement of the needle into the disc; finally, anteroposterior view was used only to check the correct position of the tip of the needle (Fig. 1a, b).

The needle was inserted into the disc to be treated, and after making sure that it was correctly positioned, the procedure could be performed. In both groups, a 17-gauge needle available in the kit was used; after the withdrawal of the stylet, the device could be inserted.

PCN was performed using a coblation catheter inserted into the introducer needle; then, the fibre of the Perc-DC SpineWand (ArthroCare co., Sunnyvale, CA, USA) was connected to the Arthrocare power generator (Fig. 2a, b). If the patient experienced any pain during the ablative procedure, the needle tip was repositioned in the targeted disc. Void number, duration and ablation intensity were all adjusted according to the size and hardness of the herniated disc.

Conversely, in the PCD group, a manual discectomy was carried out introducing a probe (DISKOM percutaneous discectomy probe, Biopsybell, Mirandola, Italy) into the cannula of the needle. The probe was locked to the access needle through the luer lock connection and switched on. A continuum movement in the anteroposterior direction and a rotary movement were applied for 2/3 min. Disc material was then removed and collected along the probe stylet or into the collection chamber (Fig. 3a–d). After switching off, the device could be removed.

In both the treatment groups, the estimated removed disc material was approximately 1 ml.

All patients were monitored during the operation, and ECG, blood pressure and oxygen saturation were measured.

Overall procedure time, fluoroscopy time and radiation dose administered were recorded.

The overall procedure time was registered as the time from the patient positioning on the angiographic bed and the end of the procedure itself (output of the patient from the angiographic suite). The radiation dose was expressed in terms of dose area product (DAP, Gy * cm^2).

Complications were classified into “major” and “minor” according to the CIRSE classification system [9].

Pre-operative antibiotic prophylaxis with a cephalosporin was administered. Patients were observed during almost 3-h bed rest and were discharged on the same day. If necessary, nonsteroidal anti-inflammatory drugs and analgesics (paracetamol) were prescribed during the first week. B12

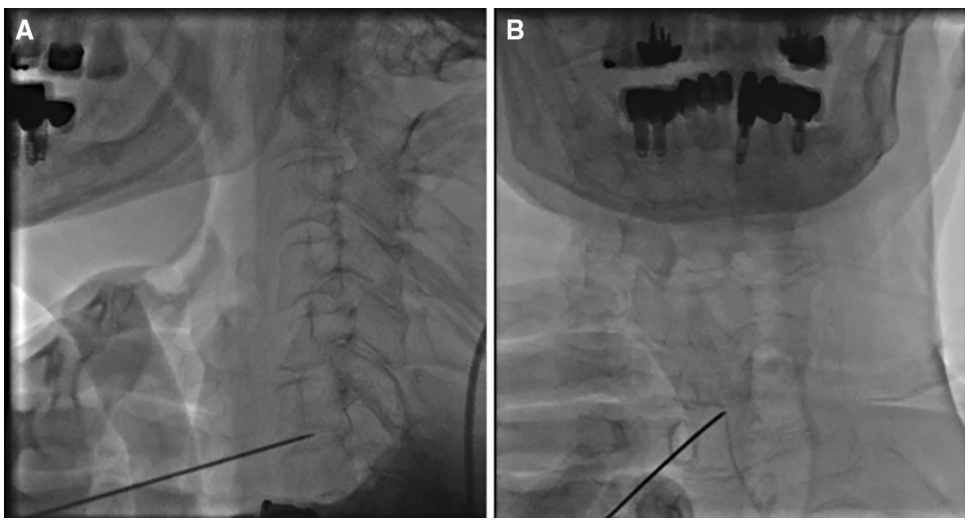

Fig. 1 **a**, **b** Lateral C-arm fluoroscopic image obtained to deploy the needle into the disc to be treated (**a**); anteroposterior view is used only to check the correct position of the tip of the needle (**b**)

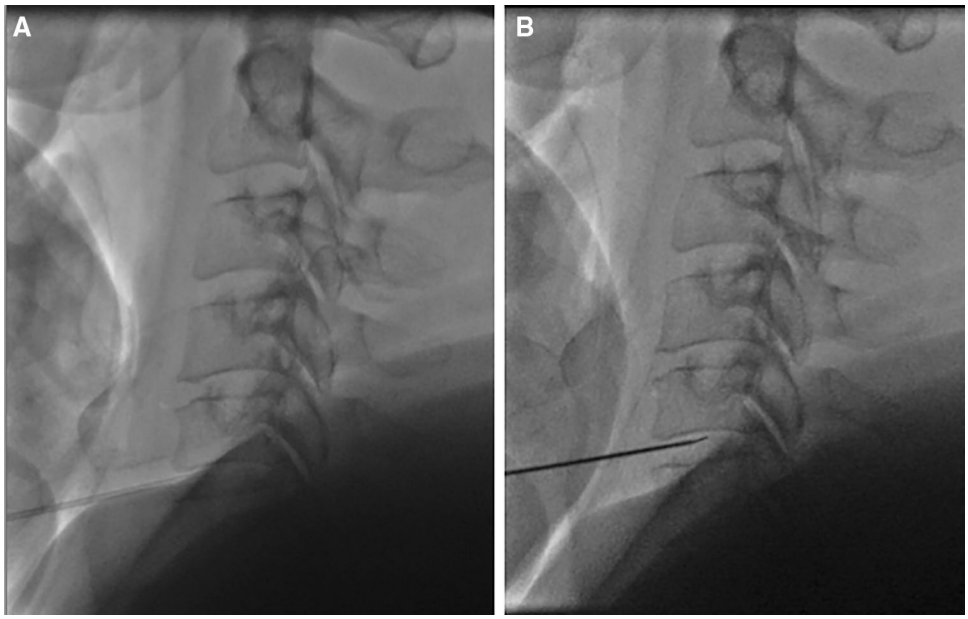

Fig. 2 **a**, **b** PCN (percutaneous nucleoplasty): fluoroscopic lateral view after the removal of the stylet (**a**) and the insertion of the coblation catheter into the introducer needle (**b**)

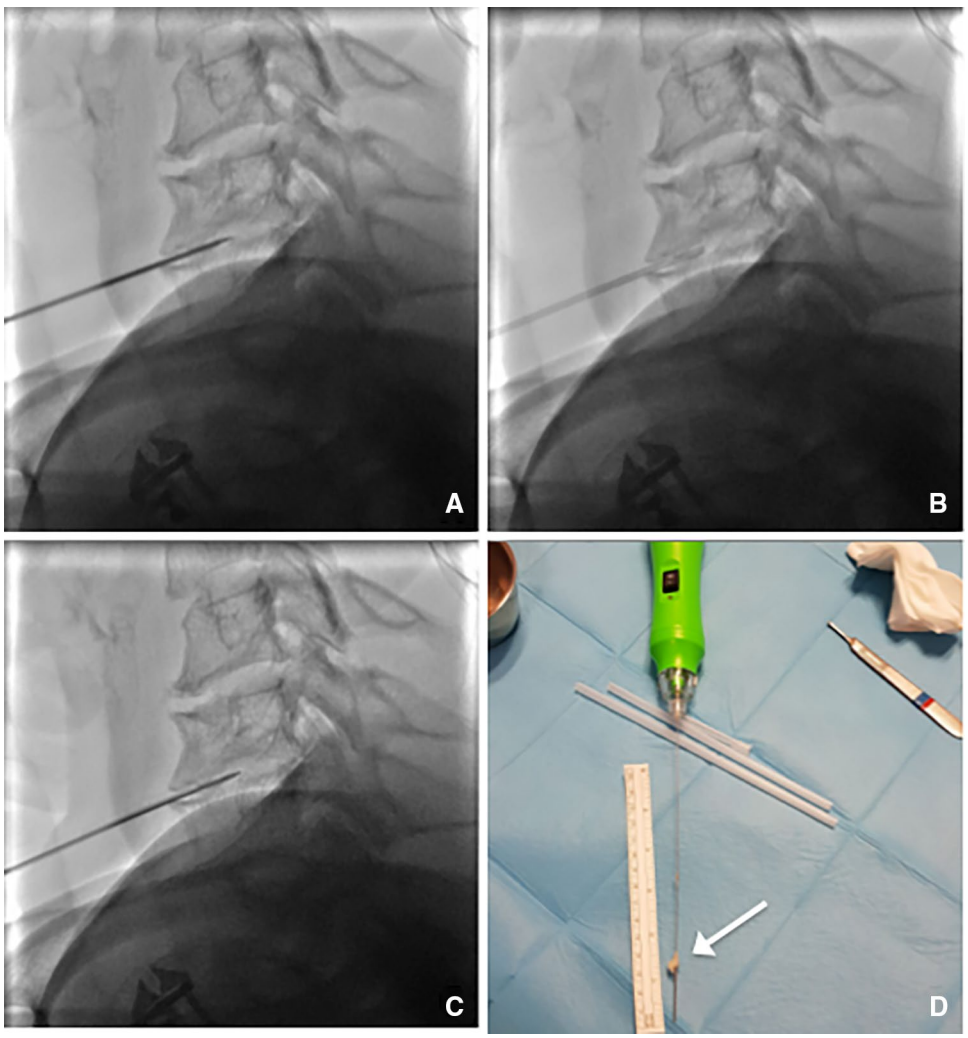

Fig. 3 **a**–**d** PCD (percutaneous discectomy): correct position of the needle into the disc (**a**); image obtained after the removal of the stylet (**b**); intra-procedural image obtained with the probe into the cannula of the needle (**c**); disc material removed and collected along the probe stylet (**d**)

vitamin for at least 15 days after the procedure were also prescribed.

The MacNab scale score was used to assess clinical success in terms of pain relief at 2- and 6-month follow-up (graded as excellent, good, fair and poor).

After 4–6 months, a cervical MRI follow-up was obtained in 24 patients.

Statistical analysis

Student's t-test in comparison with Fisher exact test was used to evaluate the correlation between overall clinical outcomes at 2 and 6 months (graded by modified MacNab criteria) and treatment choice (PCN or PCD).

A p value < 0.05 was considered statistically significant. IBM SPSS Statistics for Windows, Version 25.0 (Armonk, NY: IBM Corp) was used for all statistical analyses.

Results

Procedural data

The average overall procedure time was 18 min and 23 s (range 12–23 min) for PCN and 19 min and 9 s (range 15–25 min) for PCD.

The average fluoroscopy time was 3 min and 7 s (range 1 min 10 s–3 min 50 s) for PCN, whereas it was 3 min and 5 s (range 2 min 15 s–3 min 55 s) for PCD.

The average radiation dose was 28 Gy cm^2 (range 22.2–30.4 Gy cm^2) for PCN and 29.4 Gy cm^2 (range 22.2–32.2 Gy cm^2) for PCD; therefore, median overall radiation dose was found to be slightly inferior using PCN, even if no significant statistical difference was registered.

No procedural complications were reported.

Clinical outcome and MRI follow-up

Regarding patient satisfaction, overall median modified MacNab score was excellent both at 2 and 6 months after treatment (Table 2).

Student's t-test showed no significant statistical difference in mean modified MacNab score at 2 and 6 months among patients grouped by treatment choice ($p = 0.319$ and 0.847, respectively; see the boxplot graph in Figs. 4, 5).

Among patients who had received an MRI follow-up, four and two patients from treatment group A and B, respectively, complained of a poor clinical outcome, and imaging reassessment was consequently provided. The correlation of MRI findings with patient satisfaction is shown in Table 3.

Discussion

Symptomatic cervical radiculopathy is a common clinical scenario associated with considerable morbidity, social burden and economic impact. Only a few large series, such as the vastly quoted study from the Rochester group of Radhakrishnan et al. [10] and the one by Schoenfeld et al. [11], have sought to determine the epidemiology of cervical radiculopathy. According to the authors, the annual incidence of cervical radiculopathy ranges from 0.63 to 1.79 per 1000 persons.

Numerous operative and non-operative treatment approaches have been proposed over the years. In neurologically stable patients, conservative treatment is widely accepted as the first-line therapeutic option, with pain relief and substantial reduction in disability reported in about 40% of cases [12]. Early surgical treatment is nowadays mostly fostered in patients presenting with progressive neurological symptoms or clinical signs of myelopathy [13].

When conservative management fails, with symptom persistence or worsening, surgery may be considered. Burneikiene et al. [14] have successfully demonstrated that symptom duration is a key determinant of surgical outcome, and patients treated within the first 6 months from clinical onset have a more satisfactory improvement in symptoms.

Nevertheless, there is no clear established consensus, either on general management or on the most appropriate timing to resort to elective surgery [13], and decision-making is often based on the experience of the individual physician and local production volume.

Table 2 Clinical outcome in terms of patient satisfaction at 2 and 6 months in the two treatment groups

	Percutaneous discectomy (Group A)			Percutaneous nucleoplasty (Group B)		
	Excellent	Good	Fair/poor	Excellent	Good	Fair/poor
MacNab at 2 months	11	9	4	14	8	2
MacNab at 6 months						
Excellent	10	2	1	11	1	0
Good	1	6	1	3	6	1
Fair/poor	0	1	2	0	1	1

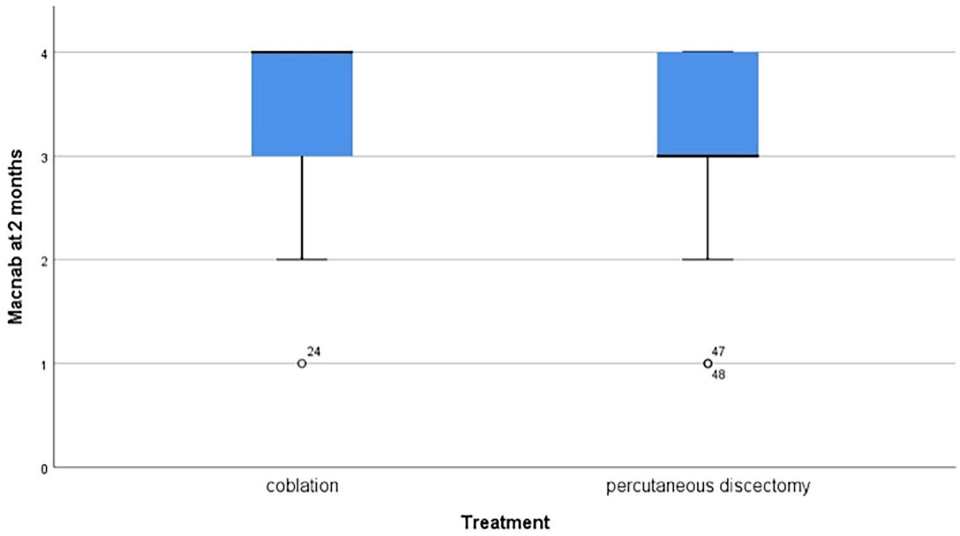

Fig. 4 Boxplot graph showing clinical outcomes in terms of patient satisfaction evaluated by the MacNab score at 2 months after the minimally invasive procedures

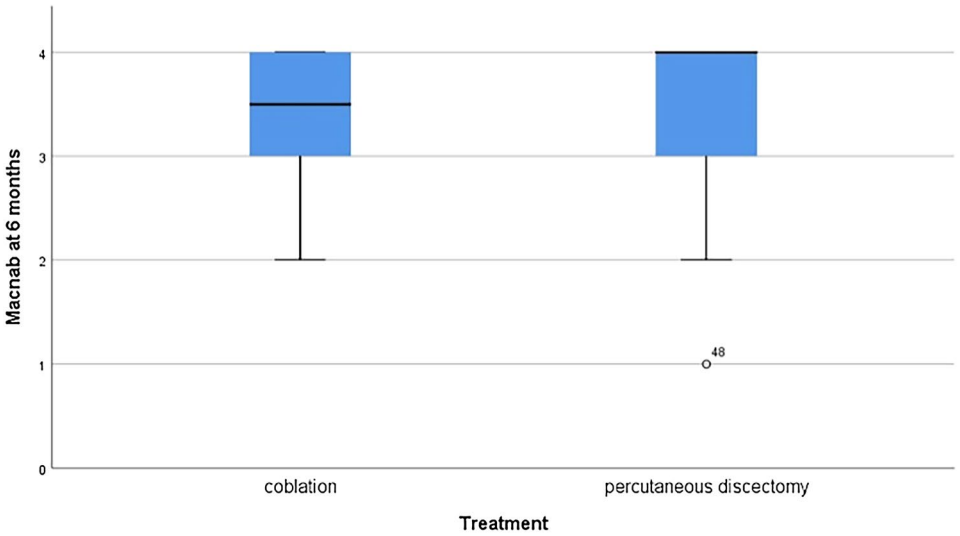

Fig. 5 Boxplot graph showing clinical outcomes in terms of patient satisfaction evaluated by the MacNab score at 6 months after the minimally invasive procedures

Table 3 Correlation of clinical success with MRI findings in patients who had received imaging follow-up

	Percutaneous discectomy (Group A)			Percutaneous nucleoplasty (Group B)		
	MacNab at 4–6 months			MacNab at 4–6 months		
	Excellent	Good	Fair/Poor	Excellent	Good	Fair/Poor
Post-operative MRI findings	5	1	4	7	5	2
Disc herniation regression (complete or partial)	4	1	0	7	4	1
Persistent disc herniation	1		4	0	1	1

Open surgical treatments range from conventional anterior discectomy and fusion to artificial disc replacement, with the former remaining the most commonly performed procedure in single-level cervical disc herniations [15]. Because of poor general performance status or comorbidities, not all patients are considered eligible for an open approach, and, even if good candidates, they may refuse the intervention. Moreover, surgery invariably entails the risk of peri-operative complications, which must always be considered in the assessment of the risk–benefit ratio.

Given the need to bridge the gap between non-operative treatments and open invasive procedures, the current trend

of evolution in spinal surgery has been towards patient-tailored techniques and reduction in surgical-related trauma; in recent years, a variety of imaging-guided percutaneous minimally invasive approaches have been proposed for the treatment of discogenic pain and radiculopathy-related disability, with the aim to obtain disc decompression. Indeed, Castro et al. [16] have verified the biomechanical changes behind the clinical success of percutaneous discectomy: the authors found that the removal of a certain amount of nucleus pulposus material, though increasing radial bulge, unequally results in the reduction in disc height and internal pressure, thereby postulating the pivotal role of tension decline in symptom improvement.

The ideal selection criteria for percutaneous approach include small-to-medium-sized hernias and symptomatic single-level contained cervical disc herniation with negligible disc degeneration [17]. Contraindications are represented by segmental instability, sequestered or calcified disc, prominent osteophytes, severe degenerative disc disease, discitis, neural foramen or spinal canal stenosis, malignancy, previous disc surgery at the same level, impaired coagulation and pregnancy [17].

Mechanical, thermal and chemical decompression, together with biomaterial implantation techniques, is currently employed. In the last decade, a discrete number of validation studies have been published on individual techniques [17].

Our results showed no significant statistical difference in mean modified MacNab score at 2 and 6 months among patients grouped by treatment choice. Average success rates, visual analog scale (VAS) evaluation of pain relief, neck disability index values and overall patient satisfaction are indeed mostly solid and concordant for all percutaneous approaches [18]. In 2010, a randomized controlled trial (RCT) by Cesaroni and Nardi [19] demonstrated that percutaneously treated patients exhibited better outcomes at 1-year follow-up compared to the conservative control arm. In 2011, the RCT by Erginousakis et al. [20] comparing percutaneous discectomy and non-operative treatments favored the former, with statistically significant reduction in disability and long-lasting pain relief. Conversely, in 2017, a review of the literature and meta-analysis by Epstein [21] found no significant difference in the reported outcome after laser discectomy and thermo-annulo-nucleoplasty techniques compared with non-surgical treatment. However, it is evident that compared to traditional open surgical procedures, percutaneous ablative techniques are accompanied by less extensive tissue damage and subsequent complications. Other than that, percutaneous techniques are safe and cost-effective, allowing outpatient surgery under local anaesthesia [22].

In our series, we retrospectively compared two different percutaneous techniques: percutaneous cervical nucleoplasty (PCN) and percutaneous cervical discectomy (PCD). These are minimally invasive procedures meant to mechanically reduce the volume of the nucleus pulposus and relieve pressure on the involved nerve root. PCN is a percutaneous disc decompression technique based on coblation technology: a bipolar probe delivers radiofrequency energy, generating a plasma field of ionized particles inside the disc nucleus. Released energy is able to break chemical bonds, partially dissolving the nucleus pulposus into its constituent molecules and a proportional amount of gas. Furthermore, coagulation and contraction of the collagen reticulum occurs.

Instead, PCD relies on opening a window through the outer fibrous ring of the herniated disc and removing nucleus fragments by suction. Different systems for mechanical removal of disc material have been employed in some series, mainly in the lumbar spine, including the use of spiral tips [23].

PCD and PCN have been extensively employed and evaluated both in lumbar and cervical radiculopathy treatment. Wullems et al., summarizing the outcome results of multiple RCT and non-randomized studies, found a satisfactory or good-to-excellent outcome in $\geq$ 77.3% of PCN procedures.

Based on the MacNab criteria, surgical outcomes of cervical PCD have been reported to be excellent, good or at least fair in most trials, with success rates ranging from 51 to 94.5% [24]. In 2004, Ahn et al. [24] observed a significant improvement in pain and disability in more than 88% of patients treated by this technique.

In our series, patient satisfaction evaluated at 2-month follow-up with the modified MacNab score was good to excellent in 91.7% of PCN and 83.3% PCD procedures. Half of the patients complaining of a poor outcome perceived an improvement in symptoms at the 6-month follow-up. Moreover, among patients who received an MRI reassessment, imaging features were concordant with patient perception of outcome.

We have demonstrated that both PCN and PCD are safe approaches. In the literature, percutaneous decompression is associated with infrequent and mild complications; nonetheless, even minimally invasive procedures, like PCD and PCN, entail the potential risk of complications [9]. These include infections, bleeding, nerve damage, worsening of pain and recurrence of herniation. Discitis is the most commonly reported early post-operative complication, being more frequently observed with coblation rather than with PCD [8]. Manoeuvre failure, caused by equipment breakage, represents one procedural contingency to be considered. Both groups of Yan and Yang [2, 8, 9, 25] described the intraoperative rupture of a SpineWand into the discal space during PCN. In our series, until the last follow-up check, there has been no concerning event or undesired periprocedural symptoms.

In addition to the retrospective single-centre nature of our study, some limitations merit consideration. Even if the patients included in the two groups were quite homogeneous in terms of age range and similar clinical and imaging features, some biases are unavoidable. Another limitation was that the post-operative MacNab scores were assessed only 2 and 6 months after the procedure, which is a relatively short follow-up period. Moreover, we were unable to obtain an MRI reassessment in all the patients. Larger patient cohorts and randomized clinical studies are required to define the clinical benefits of one technology over the other, and with open surgical treatment in terms of safety and patient outcomes.

Conclusion

PCD and PCN are both minimally invasive procedures, which have proven to be safe and effective in terms of pain relief in contained cervical herniation treatment. In our cohort, no differences were observed between the techniques regarding clinical outcome and complications at 2- and 6-month clinical follow-up.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval 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. The present study is a retrospective study: for this type of study formal consent is not required.

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

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