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CASE SERIES

The potential impact of various diagnostic strategies in cases of chronic pain syndromes associated with lumbar spine degeneration

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Andrey Bokov
Olga Perlmutter
Alexander Aleynik
Marina Rasteryaeva
Sergey Mlyavykh

Scientific Research Institute of Traumatology and Orthopedics, Nizhniy Novgorod, Russian Federation

Purpose: To study the possible effects of various diagnostic strategies and the relative contribution of various structures in order to determine the optimal diagnostic strategy in treating patients with noncompressive pain syndromes.

Study design: Prospective, nonrandomized cohort study of 83 consecutive patients with noncompressive pain syndromes resistant to repeated courses of conservative treatment. The follow-up period was 18 months.

Results: Nucleoplasty was effective in cases of discogenic pain; the consequences related to false positive results of the discography were significant. The most specific criterion was 80% pain relief after facet joint blocks, whereas 50% pain relief and any subjective pain relief were not associated with a significant increase in the success rate. A considerable rate of false negative results was associated with 80% pain relief, whereas 50% pain relief after facet joint blocks showed the optimal ratio of sensitivity and specificity. Facet joint pain was detected in 50.6% of cases (95% confidence interval 44.1%–66.3%), discogenic pain in 16.9% cases (95% confidence interval 9.5%–26.7%), and sacroiliac joint pain in 7.2% cases (95% confidence interval 2.7%–15%). It was impossible to differentiate the main source of pain in 25.3% of cases.

Conclusion: It is rational to adjust the diagnostic algorithm to the probability of detecting a particular pain source and, in doing so, reduce the number of invasive diagnostic measures to evaluate a pain source. False positive results of diagnostic measures can negatively affect the overall efficacy of a particular technology; therefore, all reasons for the failure should be studied in order to reach an unbiased conclusion. In choosing diagnostic criteria, not only should the success rate of a particular technology be taken into consideration but also the rate of false negative results. Acceptable diagnostic criteria should be based on a rational balance of sensitivity and specificity.

Keywords: diagnostic strategy, lumbar spine, noncompressive pain, sensitivity, specificity

Introduction

Chronic pain syndromes associated with degenerative diseases of the lumbar spine remain a problem because of the high prevalence of these morbid conditions; pain syndromes without nerve root compression form the majority of cases.[1–3]

It has been reported that target-specific minimally invasive interventions can cause problems due to difficulties in detecting the main source of pain, but are, nevertheless, essential to achieve at least satisfactory results.[4–7] The classification of pain syndromes, based on the prevalence of axial or leg pain, can complicate the diagnostic process because pseudoradicular complaints could be a component of noncompressive pain syndromes.[7–13] It is evident that diagnostic interventions should be applied in order to validate the pain source; however, it has been reported that discography could have a significant frequency

Correspondence: Andrey Bokov
Scientific Research Institute of Traumatology and Orthopedics, Verkhnyaya Volzhskaya Naberezhnaya – 18, Nizhniy Novgorod 603155, Russian Federation
Tel +7 910 798 5159
Fax +7 831 278 7901
Email andrei_bokov@mail.ru

of false positive results.[14–16] Diagnostic facet joint blocks is a subjective method because of the necessity of using the visual analog scale (VAS) to assess the results.[6] Furthermore, various authors use different criteria to validate it.[17–19]

Nucleoplasty and radiofrequency facet joint denervation have been reported to be an effective treatment option in cases of noncompressive discogenic pain and facet joint pain, respectively, in both short- and long-term results.[18–25] In the majority of studies, different pain syndromes have been studied separately with emphasis on the efficiency of the particular treatment modality; however, a particular diagnostic strategy could also influence the frequency of clinically significant results. Furthermore, the reported low frequency of clinically significant results in some studies could reflect the disadvantages of the applied diagnostic algorithm and could be partly relevant to the intervention used. Studying the possible effects of various diagnostic strategies and the relative contribution of various structures could be beneficial in order to determine the optimal diagnostic strategy in treating patients with noncompressive pain syndromes.

Study design

This study was a prospective, nonrandomized cohort study of 83 patients presenting with a noncompressive pain caused by degenerative processes of the lumbar spine. The participants underwent surgical interventions during the period of March 2009 to October 2010; 25 patients were treated with nucleoplasty and 62 with radiofrequency denervation of facet joints. The results of nucleoplasty were analyzed in 25 participants (100%) and the results of radiofrequency denervation of facet joints in 58 cases (93.5%). According to the results of diagnostic procedures and minimally invasive interventions, a conclusion was made in regard to the contribution of various structures in pain syndromes associated with the degenerative processes. Also, the impact of the diagnostic strategy on the results of the minimally invasive procedures used was studied.

Inclusion criteria

Patients that presented with pain syndromes caused by degenerative processes in the lumbar spine (lumbalgia, lumbosciatalgia) were selected for this study using the following selection criteria:

- No evidence of nerve root compression according to the results of physical examination and neuroimaging;
- Patients resistant to at least 1 month of a conservative therapy (including different types of blocks with corticosteroids);
- Pain intensity of no less than 40 on the 100-point VAS and no less than 40 on the Oswestry Disability Index (ODI).

The potential benefits, risks, advantages, and disadvantages were explained, and written informed consent was received from all participants (concerning the applied type of surgery and participation in the study).

Exclusion criteria

The exclusion criteria were:

- Litigation;
- Uncontrolled psychological disorders;
- Evidence of nerve root compression;
- Evidence of spinal stenosis, infection, and tumors;
- Spinal surgery in anamnesis (any type).

Preprocedural diagnostic evaluation

Before the interventions, all participants were given a neurological examination. Initially all of them presented with a noncompressive pain pattern; in all cases, they were negative in regard to nerve root tension symptoms and neurological deficit.[26] All participants were examined preoperatively using the VAS (scale of 0–100 was applied) and ODI questionnaire version 1.[27–29] All patients underwent magnetic resonance imaging tomography (1,5 T Siemens Magnetom Symphony, Siemens AG Healthcare Sector, Erlangen, Germany). Computer myelography was applied in case of pseudoradicular pain pattern in addition to magnetic resonance imaging to exclude nerve root compression. Discography was utilized to reproduce pain in cases when discogenic origin of pain was suspected. The reproduction of pain was classified as concordant, partly concordant, discordant, and negative; standard technique using lateral extrapedicular approach was applied.[30,31] Diagnostic facet joint blocks were performed twice in sterile conditions under the guidance of fluoroscopy (General electric OEC 9800 Plus, Van Buren Charter Township, MI, USA) with two different anesthetics of different time action. Needles were introduced using standard landmarks for the medial branch location (junction of the upper border of the transverse process base and the lateral border of the upper articular process base). At least two of the adjacent medial branches – the nerve supply of the supposed source of pain – were blocked on each side. No more than 0.5 mL of anesthetic was injected to block each medial branch. Different types of anesthetic were used perform diagnostic blocks (novocaine, lidocaine, bupivacaine). The results were classified as any subjective pain relief, at least 50% pain relief, and at least 80% pain relief during

the anesthetic action. Sacroiliac joints blocks were applied to determine the reasons for failure after nucleoplasty and radiofrequency facet joint denervation. Different types of anesthetic were used to perform diagnostic blocks under the control of fluoroscopy using anesthetics of different time action as described by Maigne et al.[32]

Surgical interventions

Nucleoplasty was performed by several surgeons in sterile conditions under the guidance of fluoroscopy; six channels were created within the disc using a radiofrequency wand (ArthroCare System Controller 2000, ArthroCare Corporation, Austin, TX, USA), applying an ablation and coagulation mode. The surgical technique was standard without acceptance of any variances, as described elsewhere.[21,22,33]

Radiofrequency facet joint denervation was performed by several surgeons in sterile conditions under the guidance of fluoroscopy. Thermal lesions of medial branches were performed using 22 G radiofrequency probes with a 5 mm active tip (RF Lesion Generator system RFG-3C Plus, Integra Radionics Inc, Burlington, MA, USA). The medial branch lesion was performed on at least two adjacent levels, proven to be the nerve supply of pain source. After the radiofrequency lesioning of medial branches was performed at temperature 80°C for 60 seconds. The conventional technique of radiofrequency facet joint denervation has been previously described.[18,34]

Outcome measures

Participants were examined after 1 month, 3 months, 6 months, 12 months, and 18 months. No less than 50% pain intensity relief applying the VAS and at least a 40% decrease in the ODI score were considered to be clinically significant.[35,36] The 6-month period was the cutoff between long-term and short-term results for facet joint denervation and 12 months for the nucleoplasty cases.[6] Facet joint diagnostic blocks and sacroiliac joint blocks were applied postoperatively to determine the reasons for failure after the minimally invasive procedures.

Statistical analysis

Various statistical criteria were applied for the analysis of data sets. Fisher's exact test was used for dichotomized data sets; if a statistically significant difference was established, the logistic regression analysis was applied (quasi-Newton algorithm). For continuous data sets, the normality test (Shapiro–Wilk test), Wilcoxon test, Kruskal–Wallis test, and Friedman test were used. Statistical power was calculated twice (planning the study and a posteriori) using the Monte Carlo method (2000 simulations). The Anderson–Darling, Kolmogorov–Smirnov, and Pearson's Chi-squared goodness of fit tests were applied for the distribution fitting of the data sets (required for the statistical power calculation using the Monte Carlo method).

Results

Prior to treatment, patients presented with noncompressive pain syndromes; in 52 cases there was a domination of axial pain and 31 patients presented with a pseudoradicular syndrome (a prevalence of leg pain; however, the symptoms of nerve root tension were negative and no neurological deficit was evaluated).

In 22 cases, the clinical findings were similar to those described in manuscripts dedicated to the study of facet joint syndrome presentation.[37,38] The decision to perform radiofrequency facet joint denervation was based on:

- Clinical presentation;
- Evidence of facet joint degeneration from imaging results;
- Reproduction of pain during pain provocation before radiofrequency lesioning.

In 61 cases, the decision to perform discography and diagnostic facet joint blocks was based on:

- Disc height no less than 50% of normal – discography was applied;
- Negative results of discography – repeated facet joint blocks were administered;
- Disk height loss more than 50% – repeated facet joint blocks were administered.

Of the discographies performed, only 25 cases experienced a concordant pain reproduction; those patients were treated with nucleoplasty. In 36 cases, repeated facet joint blocks were administered. The results of facet joint blocks were classified as any subjective pain relief, at least 50% pain relief, and 80% pain relief according to the results of VAS application. All 36 patients presented with subjective pain relief, but only 26 presented with at least 50% pain relief and eleven presented with 80% pain relief. In all cases of subjective pain relief, radiofrequency facet joint denervation was applied. The demographic data are presented in Table 1.

After nucleoplasty, eleven (44%) patients presented with unsatisfactory results. To find the reasons for nucleoplasty failure, facet joint blocks were applied and nine of the eleven patients experienced at least 80% pain relief during the time of the anesthetic action, thereafter the hyperdiagnostics of discogenic pain was evident. After the nine patients had been excluded, the results of nucleoplasty were reassessed

Table 1 The demographic characteristics of the enrolled patients

	RF facet joint denervation without facet block administration	Minimally invasive procedures performed after discography and facet joint blocks	
		Nucleoplasty	RF denervation of facet joints
n	22	25	36
Female	16	12	26
Age	M = 51.3812 ± 2.8614 SD = 13.4213	M = 43.9600 ± 2.1404 SD = 10.7023	M = 51.8333 ± 2.0226 SD = 12.1361

Abbreviations: M, mean; RF, radiofrequency; SD, standard deviation.

and this procedure turned out to be positive in both the short- and long-term. The dynamics of the VAS and the ODI scores are presented in Tables 2–4. After nucleoplasty, statistically significant decreases in pain intensity and pain disability were observed ($P = 0.0006$ and $P = 0.0008$, respectively). Throughout the period of observation, no statistically significant changes were observed in pain intensity and pain disability ($P = 0.8817$ and $P = 0.4813$, respectively; Friedman test). In all cases of clinically significant pain relief, the results were consistent throughout the period of observation.

It is obvious that in a considerable number of cases the results of provocative discography were false positive. Even though the proportion of patients treated with nucleoplasty was low, the negative input of discogenic pain hyperdiagnostics was statistically significant (proportions of clinically significant results were 14/16 versus 14/25 if diagnostic facet blocks were not introduced into the diagnostic algorithm prior to discography; $P = 0.0477$).

In cases when the decision to apply radiofrequency denervation was based on clinical findings and the results of imaging, the rate of clinically significant results within the first 3 months was only 13 out of 22. Within 6 months, it was only twelve out of 22, followed by a further reduction in the number of patients presenting clinically significant results because of medial branch regeneration proven by diagnostic facet joint blocks (Table 5). The reasons for failure were sacroiliac joint pain in one case, complex biomechanical impairment of spinal segments that could not be reduced to the pathology of a particular structure in six cases, and undetermined source of pain in two cases.

The application of facet joint blocks with making diagnostic criteria gradually stricter was analyzed in a group of 36 patients (Table 5). In cases when any subjective pain relief was applied as a diagnostic criterion, the rate of clinically significant results was the same as when there was no application of facet joint blocks. By introducing a restriction (50% pain intensity relief applying VAS), it became possible to exclude ten cases with negative results of facet joint denervation. Further restrictions (80% pain relief applying VAS) resulted in a statistically significant increase in the clinically significant results rate within the first 6 months, but it produced nine false negative results in regard to the prediction of clinically significant results at 12–18 months. This effect is statistically significant (zero false negative results if 50% pain relief was applied as the criterion versus nine false negative results if 80% pain relief was applied; $P = 0.0012$ for 6-month results).

The regeneration of medial branches within the 6–12-month period of observation neglected the estimated differences (the regeneration of medial branches was confirmed by the results of facet joint blocks). The reasons for unsatisfactory results were studied in a group of patients treated with radiofrequency facet joint denervation after application of diagnostic blocks. The sacroiliac joints were the dominant pain source in five cases, the biomechanical impairment of spinal segments in eight cases, and the source of pain was not able to be detected in three cases. It should be mentioned

Table 2 The dynamics of pain intensity and pain disability after nucleoplasty application

	Pain intensity before nucleoplasty	Pain intensity 1 month after nucleoplasty	Pain disability (ODI) before nucleoplasty	Pain disability (ODI) after nucleoplasty
N	16	16	16	16
Mean	66.3333	14.80	57.8667	13.5333
Median	60.0	10.0	58.0	12.0
UQ	70.0	20.0	68.0	16.0
LQ	50.0	0.0	46.0	0.0

Abbreviations: LQ, lower quartile; ODI, Oswestry Disability Index; UQ, upper quartile.

Table 3 The dynamics of pain intensity throughout the observation period

	1 month	3 months	6 months	12 months	18 months
N	16	16	16	16	16
Mean	14.80	16.3333	15.3333	16.0	15.6667
Median	10.0	10.0	10.0	10.0	10.0
UQ	20.0	25.0	15.0	20.0	20.0
LQ	0.0	10.0	10.0	10.0	10.0

Abbreviations: LQ, lower quartile; UQ, upper quartile.

that nine patients out of 20 with clinically significant results of facet joint radiofrequency denervation initially presented with a pseudoradicular syndrome (domination of leg pain with lateralization). According to the results, the overall effect of facet joint blocks being introduced into a diagnostic algorithm with the criterion of 50% pain relief in all cases of noncompressive pain syndromes increased the efficacy of minimally invasive treatment by diminishing the hyperdiagnostics of discogenic pain and the number of cases in which the cause of pain syndrome could be simplified down to the pathology of facet joints only (the rate of clinically significant results was 55.3% [95% confidence interval 41.1%–69.5%] if facet joints blocks were not applied versus 84% [95% confidence interval 74.3%–94.2%] if applied in all cases of noncompressive pain syndromes; $P = 0.0037$, Fisher's exact test).

According to the results of this study, the facet joint was detected as the main source of pain in 50.6% of cases (95% confidence interval 44.1%–66.3%); discogenic pain in 16.9% of cases (95% confidence interval 9.5%–26.7%), and sacroiliac joint pain in 7.2% cases (95% confidence interval 2.7%–15.0%). It was impossible to differentiate the main source of pain in 25.3% of cases.

Discussion

It has been reported that the evaluation of the main pain source in cases of spine degenerative diseases could be associated with certain difficulties. Because of the same segmental innervation, the patterns of pain originating from different structures could bear some resemblance.[39–45] Furthermore, every movement of the lumbar spine involves all vertebral segments, therefore clinical provocative tests without application of diagnostic interventions can hardly determine the cause of pain syndrome.[17,46–48] In the current study, it was determined that cases of discogenic pain and facet joint pain could present with a pseudoradicular syndrome that can be misleading in the attempt to evaluate discogenic pain. The significant rate of false positive pain provocations when applying discography could result in a considerable number of diagnostic mistakes and affect the success rate of nucleoplasty. The interference of these errors must be taken into consideration when studying the results of intradiscal interventions in order to make a valid conclusion in regard to the efficacy of the particular intervention used. The results of the current study show that nucleoplasty is effective in cases of noncompressive discogenic pain; however, false positive results of discography could have a negative effect on the results of nucleoplasty. Apparently, because of the attempt to apply a diagnostic algorithm with an emphasis on diagnosing discogenic pain in cases of pseudoradicular pain presentation and because of false positive results of discography, the hyperdiagnostics of discogenic pain could be one of the frequent diagnostic mistakes.

Diagnostic facet joint blocks proved to be the only method that provided a valid conclusion on pain origin; nevertheless, the information concerning the optimal criteria remains controversial. Although 80% of pain relief after facet joint blocks is recommended as the criterion of facet joint pain diagnosis, some authors apply the criterion of 50% or 70% pain relief.[4,6,17–19,49] Using any pain relief as a criterion of facet joint pain without VAS application, no statistically significant increase in the rate of clinically significant results

Table 4 The Oswestry Disability Index dynamics throughout the observation period

	1 month	3 months	6 months	12 months	18 months
N	15	15	15	15	15
Mean	13.5333	14.9333	14.2667	14.2667	13.8667
Median	12.0	12.0	12.0	12.0	12.0
UQ	16.0	16.0	16.0	18.0	16.0
LQ	0.0	8.0	8.0	8.0	10.0

Abbreviations: LQ, lower quartile; UQ, upper quartile.

Table 5 Analysis of the clinically significant results rate after radiofrequency denervation using different diagnostic criteria and significant difference in success rate compared with that registered in cases when diagnostic blocks were not applied

	1 month	3 months	6 months	12 months	18 months
Clinic, imaging, pain provocation (n = 22)	13 (59%)	13 (59%)	12 (54%)	8 (36%)	4 (18%)
Any subjective pain relief (n = 36)	23 (64%) $P = 0.7841$	20 (55%) $P = 0.9999$	20 (55%) $P = 0.9999$	12 (33%) $P = 0.9999$	9 (25%) $P = 0.7475$
50% pain relief (n = 26)	23 (88%) $P = 0.0420$	20 (77%) $P = 0.2227$	20 (77%) $P = 0.1310$	12 (46%) $P = 0.5651$	9 (35%) $P = 0.3288$
80% pain relief (n = 11)	11 (100%) $P = 0.0150$	11 (100%) $P = 0.0150$	11 (100%) $P = 0.0129$	6 (54%) $P = 0.4587$	3 (27%) $P = 0.6610$

was achieved. According to the current results, if an 80% criterion was applied, a statistically significant increase in the rate of clinically significant results could be achieved, compared with that estimated in the group without facet block application; however, the loss of sensitivity could be another potential effect of this specificity increase. By applying a 50% pain relief criterion, it became possible to predict the failure of facet joint denervation in ten cases. In addition, no false negative results using this criterion were observed. By making the criterion stricter (80% pain relief), a maximal exclusion of false positive results of diagnostic blocks was achieved, although a considerable number of false negative results was observed in predicting the result of facet joint denervation. It is questionable whether such a tactic is rational in daily practice because the procedure of radiofrequency facet joint denervation was proven to be safe and capable in providing short- and long-term pain relief in cases of pain caused by facet joint degeneration.[36,50] False negative results could necessitate the application of more aggressive modalities or the elongation of treatment; however, fast recovery could have been achieved with minimally invasive treatment. In other words, false negative results of various diagnostic tools could result in a considerable negative social impact.

Analysis of the main causes of noncompressive pain syndromes reports similar results to previous reports and illustrates that facet joints are the most frequent source of chronic pain syndrome associated with degenerative processes of the lumbar spine.[4,51] In terms of this specificity, it is rational to adjust the diagnostic strategy to the probability of detecting a particular pain source. Another reason to start off with diagnostic blocks of facet joints in questionable and uncertain situations is that diagnostic and therapeutic procedures in those cases are rarely associated with complications, whereas discography and nucleoplasty could cause spondylodiscitis and it is still debatable whether those procedures could cause further degeneration of the disc.[52–56]

There are some limitations to this study. It could be criticized because it is nonrandomized. Its fusion of a population study, efficacy of diagnostic measures, and assessment of interventions could be considered a weak point; however, this design could be beneficial in disclosing the additional significant effects that could be important in daily practice.

Conclusion

It is rational to adjust the diagnostic algorithm to the probability of detecting a particular pain source and, in doing so, reduce the number of invasive diagnostic measures to evaluate a pain source. False positive results of diagnostic measures can negatively affect the overall efficacy of a particular technology; therefore, all reasons for the failure should be studied in order to provide an unbiased conclusion. In choosing diagnostic criteria, not only should the success rate of a particular technology be taken into consideration but also the rate of false negative results. Acceptable diagnostic criteria should be based on a rational balance of sensitivity and specificity.

Disclosure

The authors report no conflicts of interest in this work.

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