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Prospective Study

An Analysis of Reasons for Failed Back Surgery Syndrome and Partial Results after Different Types of Surgical Lumbar Nerve Root Decompression

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Background: Despite the evident progress in treating vertebral column degenerative diseases, the rate of a so-called "failed back surgery syndrome" associated with pain and disability remains relatively high. However, this term has an imprecise definition and includes several different morbid conditions following spinal surgery, not all of which directly illustrate the efficacy of the applied technology; furthermore, some of them could even be irrelevant.

Objective: To evaluate and systematize the reasons for persistent pain syndromes following surgical nerve root decompression.

Study Design: Prospective, nonrandomized, cohort study of 138 consecutive patients with radicular pain syndromes, associated with nerve root compression caused by lumbar disc herniation, and resistant to conservative therapy for at least one month. The minimal period of follow-up was 18 months.

Setting: Hospital outpatient department, Russian Federation

Methods: Pre-operatively, patients were examined clinically, applying the visual analog scale (VAS), Oswestry Disability Index (ODI), magnetic resonance imaging (MRI), discography and computed tomography (CT). According to the disc herniation morphology and applied type of surgery, all participants were divided into the following groups: for those with disc extrusion or sequester, microdiscectomy was applied (n = 65); for those with disc protrusion, nucleoplasty was applied (n = 46); for those with disc extrusion, nucleoplasty was applied (n = 27). After surgery, participants were examined clinically and the VAS and ODI were applied. All those with permanent or temporary pain syndromes were examined applying MRI imaging, functional roentgenograms, and, to validate the cause of pain syndromes, different types of blocks were applied (facet joint blocks, paravertebral muscular blocks, transforaminal and caudal epidural blocks).

Results: Group 1 showed a considerable rate of pain syndromes related to tissue damage during the intervention; the rates of radicular pain caused by epidural scar and myofascial pain were 12.3% and 26.1% respectively. Facet joint pain was found in 23.1% of the cases. Group 2 showed a significant rate of facet joint pain (16.9%) despite the minimally invasive intervention. The specificity of Group 3 was the very high rate of unresolved or recurred nerve root compression (63.0%); in other words, in the majority of cases, the aim of the intervention was not achieved. The results of the applied intervention were considered clinically significant if 50% pain relief on the VAS and a 40% decrease in the ODI were achieved.

Limitations: This study is limited because of the loss of participants to follow-up and because it is nonrandomized; also it could be criticized because the dynamics of numeric scores were not provided.

Conclusion: The results of our study show that an analysis of the reasons for failures and partial effects of applied interventions for nerve root decompression may help to understand better the efficacy of the interventions and could be helpful in improving surgical strategies, otherwise the validity of the conclusion could be limited because not all sources of residual pain illustrate the applied technology efficacy. In the majority of cases, the cause of the residual or recurrent pain can be identified, and this may open new possibilities to improve the condition of patients presenting with failed back surgery syndrome.

Key words: microdiscectomy, nucleoplasty, epidural scar, facet joint pain, recurrent herniation, myofascial pain

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Despite the evident progress in treating vertebral column degenerative diseases, many problems remain unresolved, and the rate of failed back surgery syndrome after surgical nerve root decompression remains considerable (1-9). The term "failed back surgery syndrome" has an imprecise definition and includes different morbid conditions following spinal surgery that are associated with persistent pain and disability (1-3). According to the results of different studies, the rate of such cases varies from 10% to 40% (10-16) and the following reasons are likely to be the most frequent: nerve root compression caused by recurrent disc herniation or retained disc fragment; epidural fibrosis; lateral and foraminal stenosis; segment instability; progressive facet joint degeneration; and myofascial pain (1-3,17-26).

The rate of nerve root compression caused by recurrent disc herniation ranges from 5 to 26% of microdiscectomies and the frequency is sometimes reported to be as high as 38% (14,15,27-32).

Epidural fibrosis is a progressive disease, which is associated with radicular pain and unfavorable outcomes after surgery. It has been reported that the rate of this source of pain accounts for up to 20-36% of all cases with failed back surgery syndrome presentation (1-9,14,15,33,34). It has been determined that this pathological process may develop as a response to tissue damage during the intervention (33,34); it also has been established that retained hematomas are likely to develop into scar tissue (35). Additionally, some studies have indicated that the material of the nucleus pulposus itself is capable of initiating aseptic inflammation in the epidural space and thus contributing to a progressive epidural fibrosis formation (36,37).

Some causes of persistent pain syndromes following surgery are likely to be associated mostly with the progression of degenerative changes; among them are spinal stenosis, facet joint degeneration, and segment instability. According to the results of other studies, the degenerative processes in a disc leading to disc height loss may provoke degeneration of other structures of the vertebral segment (17,42,47), finally resulting in different types of stenosis or segment instability (17,44,48-50).

Given this history, it was felt that an analysis of the reasons for failed back surgery syndrome as a supplement to the earlier studies which have had the objective of evaluating the efficacy of different surgical technologies focused on nerve root decompression could be helpful because not all of the reasons for this failure can be associated with the limitations or disadvantages of the applied type of surgery. Some of them represent mostly the naturally determined development of the disease or even could be irrelevant to the assessment of the technology efficacy. This analysis of the reasons for failed back surgery syndrome may help to understand better the clinical efficacy of different surgical techniques and to elaborate rational surgical strategies with clear guidelines for performing different surgical techniques. Therefore, theobjective of the present study is to evaluate and to systematize the reasons for persistent pain syndromes after different types of surgical nerve root decompression.

Methods

Study design

This is a prospective, nonrandomized cohort study of patients presenting with radicular pain associated with nerve root compression caused by disc herniation. The participants underwent surgical interventions during the period from March 2006 to October 2007; 88 patients were treated with nucleoplasty and 74 with microdiscectomy. The results of microdiscectomy were analyzed in 65 participants (88%) and the results of nucleoplasty in 73 participants (83%). 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 present study).

Inclusion criteria

Patients with pain syndromes caused by nerve root compression associated with lumbar disc herniation resistant to at least one month of conservative therapy (including different types of blocks including selective transforaminal nerve root blocks with corticosteroids) were selected for this study. The inclusion criteria were a pain intensity of no less than 40 on the 100-point Visual Analog Scale (VAS) and at least a 40% decrease on the Oswestry Disability Index (ODI). Patients were standardized by neurological deficit and only those with a mild neurological deficit were selected. Written informed consent was received from all participants.

Exclusion criteria

The exclusion criteria were litigation, uncontrolled psychological disorders, severe or progressive neurological deficit, and other serious pathological conditions which might impact the results. Those with evidence of

spinal stenosis, infection, tumors, or segment instability, and those with spinal surgery in anamnesis (any type) were excluded.

Participants' examination.

Before the interventions, all participants were given a neurological examination; initially all of them presented with compressive radicular pain pattern (prevalence of leg pain corresponding to the relevant autonomous zone of innervation).

All participants were examined preoperatively applying the VAS (scale 0-100 was applied) and Oswestry disability questionnaire V1 (51-53). All patients underwent magnetic resonance imaging tomography (MRI tomography). According to the results of MRI tomography, disc herniations were classified as a disc protrusion if the greatest distance between the edges of disc material displaced from the disc space was less than the distance between the edges of the base measured at the same plane (contained disc herniation) and was classified as an extrusion (uncontained disc herniation) when displaced disc material beyond the outer annulus had the maximal size at any plane greater then the distance between the edges of the base at the same plane on MRI images (54). Discography was utilized to certify if disc herniation was contained or not.

Surgical interventions

Nucleoplasty was performed by several surgeons in sterile conditions under the guidance of fluoroscopy; 6 channels were created within the disc using a radiofrequency wand applying ablation and coagulation mode. The surgical technique was standard without acceptance of any variances; the standard technique has been described in several manuscripts (55-57).

All microdiscestomies were performed by the same surgeon using a standard technique: transmuscular translaminar approach was applied in order to diminish tissue damage; there were no cases with damage of venous vessels during the intervention and no diathermy was used in the epidural space. The reconstruction of the lateral channel was performed in case of narrowing by hypertrophied facet joints and osteophytes. Absolute hemostasis was achieved in all cases.

Outcome measures

Participants were examined after one month, 3 months, 6 months, 12 months, and 18 months. No less than 50% pain intensity relief on the VAS and at least 40% decrease on the ODI were considered to be clinically significant; among them, cases with total pain relief were registered (25). The results were considered unsatisfactory in case of unresolved or recurred nerve root compression on the same level after the intervention. All cases with temporary, recurrent, or permanent pain syndromes after surgical interventions were analyzed. In order to validate the source of pain in these cases, MRI imaging, functional roentgenograms, computed tomography (CT) myelograms, diagnostic facet joint blocks, caudal epidural blocks, transforaminal selective nerve root blocks, and blocks of the paravertebral muscles were applied during the follow-up period in order to evaluate the reasons for persistent pain syndromes after the different types of surgery.

The recurrence of disc compression was confirmed by the results of MR tomography. For validation of other sources of pain, different types of blocks were applied repeatedly and in cases of a combination of pain sources, appropriate types of diagnostic blocks were administered.

Diagnostic facet joint blocks were performed twice in sterile conditions under the guidance of fluoroscopy with 2 different anesthetics and different action times. 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 2 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 repeatedly (novocaine, lidocaine, bupivacaine). Repeated diagnostic facet joint blocks with different types of anesthetics are known to be the only valid diagnostic method to confirm the facet joint as the origin of pain (21,58,59). At least 50% pain relief on the VAS during the time of anesthetic action was considered to be diagnostically significant for the validation of facet joint pain.

In cases when myofascial pain was suspected, paravertebral muscle blocks with anesthetic and corticosteroid were performed in order to block trigger zones, terminate muscular spasm, diminish the inflammatory process, and perform a hydraulic dissection of a postoperative scar. No less than 50% pain relief on the VAS after the procedure was the criteria for the myofascial origin of pain.

In the case of radicular pain syndrome after surgery, caudal epidural blocks, transforaminal blocks and percutaneous adhesiolysis were administered; those

interventions are known to be positive in regards to short-term and long-term pain relief in patients presenting with failed back surgery syndrome (59,60). The diagnosis of epidural adhesive process was mostly based on the combination of radicular pain corresponding to the relevant autonomous zone of nerve root innervation and the results of the MRI imaging showing epidural scar formation. In those cases, caudal epidural and transforaminal nerve root blocks with corticosteroids and hydraulic dissection of epidural structures with saline solution anesthetics provided partial pain relief. No less than 50% pain relief on the VAS was considered clinically significant.

Statistical analysis

For datasets presented in dichotomized scale, Fisher`s exact test was applied. If a statistically significant difference was established, the logistic regression analysis was applied (quasi-Newton algorithm). The power analysis was performed twice: once when planning this study in order to calculate a sample size and a posteriori by applying the Monte Carlo method.

Results

According to the disc herniation morphology and the applied surgical intervention, all participants were divided into the following subgroups:

For those with a nerve root compression caused by disc extrusion or sequester: microdiscectomy was applied (n = 65) – Group 1.

For those with a nerve root compression caused by contained disc herniation – disc protrusion. In these cases no contrast medium leakage beyond the disc space was evaluated during the discography, thereby confirming the disc herniation continuity: Nucleoplasty was applied in all cases (n = 46) – Group 2.

For those with a nerve root compression caused by uncontained herniation - disc extrusion. These participants insisted on having nucleoplasty instead of microdiscectomy. The morphological type was confirmed by MRI images and discography (the contrast medium leakage into the epidural space was evident) (n = 27) – Group 3.

Demographic characteristics are represented in Table 1. Table 2 shows the percentage of participants with total pain relief without any temporary or permanent pain syndromes presentation and those who presented at least satisfactory results throughout all the period of follow-up during 18 months.

Comparing Groups 2 and 3 it is possible to conclude that in the case of a total annulus disruption, the rate of clinically significant results and total pain relief after nucleoplasty is lower (the statistical significance was P = 0.0049 and P = 0.0024 respectively).

Table 1. *Demographic characteristics of patients' groups.*

	Group 1	Group 2	Group 3
N	65	46	27
Females	33 (50.8%)	15 (32.6%)	15 (55.5%)
Males	32 (49.2%)	31 (67.4%)	12 (44.4%)
Smoking	48 (73.8%)	22 (47.8%)	18 (66.7%)
Age	m=43.55±1.3001 SD=10.48	m=43.9783±1.7327 SD=11.7521	m=41.22±2.0481 SD=10.64

Table 2. *The rate of stable clinically significant results (at least satisfactory) and total pain relief in different groups of patients.*

	Group 1	Group 2	Group 3
N	65	46	27
At least satisfactory results	61 – 93.8% 95% CI (85%-98.3%)	36 – 73.8% 95% CI (58.9%-85.7%)	12-44.4% 95% CI (25.5%-64.7%)
The rate of total pain relief	36 – 55.4% 95% CI (42.5%-67.5%)	24 - 52,2% 95% CI (37%-67.1%)	4 – 14.8% 95% CI (4.2%-33.7%)
The rate of cases with pain syndromes presentation	44.7% 95% CI (32.3%-57.4%)	47.8% 95% CI (32.9%-63.0%)	85.2% 95% CI (66.3%-95.2%)S

Note: All cases with permamanent and temporary pain syndromes were registered.

To test the observed differences logistic regression analysis was performed and statistically significant models were estimated for the rates of total pain relief and clinically significant results:

Parameters of the regression model for clinically significant results rates, Group 2 versus Group 3: B0= –2.7850; 95% CI [–4.4065; –1.1635], $P = 0.001$. Odds ratio = 4.50; 95% CI [1.5731; 12.8727]. Goodness-of-fit $\chi 2 = 8.56212$, $P = 0.0034$.

Parameters of the regression model for total pain relief rates, Group 2 versus Group 3: B0 = –3.6270; 95% CI [–5.8627; –1.3932], $P = 0,0018$. Odds ratio = 6.2727; 95% CI [1.8328; 21.4677]. Goodness-of-fit $\chi 2 = 10.8693$, $P = 0.00098$.

Statistically significant regression coefficients confirm the association of observed differences and disc herniation morphology as explanatory factor.

Comparing Groups 1 and 3 it is possible to conclude that nucleoplasty is less effective than microdiscectomy in case of uncontained disc herniations (statistical significance for differences of at least satisfactory results and total pain relief rates presented in Table 2 was $P < 0.0001$). This conclusion is supported by the results of logistic regression analysis.

Parameters of the regression model estimated for the rates of clinically significant results, Group 1 versus group 3: B0 = –5.6723; 95% CI [–7.8636; –3.4810], $P < 0.0001$. Odds ratio = 19.0625; 95% CI [2.2870; 68.7301]. Goodness-of-fit $\chi 2 = 26.564$, $P < 0.0001$.

Parameters of the regression model for total pain relief rates, Group 1 versus group 3: B0= –2.1816; 95% CI [–3.6452; –0.7181], $P = 0.0039$. Odds ratio = 7.1379; 95% CI [2.1820; 23.3507]. Goodness-of-fit $\chi 2 = 13.963$, $P = 0.00019$. Statistically significant regression coefficients confirm that observed differences are associated with the type of the applied surgery.

According to the datasets represented in Table 2, the rate of patients presenting temporary, partially resolved, or unresolved pain syndromes throughout all the period of follow-up achieved 44.6% in Group 1; formed 47.8% in Group 2; and came to 85.2% in Group 3.

In cases of nerve root compression caused by recurrent disc herniation or retained disc fragment and cases of epidural fibrosis, pain syndromes were presented by radicular pain in the lower limbs corresponding to the relevant autonomous zone of innervation of the affected nerve root. In other cases, the pain syndrome changed to a noncompressive type profile with the prevalence of low back pain with irradiation to the buttocks or lower limbs without correspondence to exact autonomous zones of nerve root innervation.

The overall frequencies of different residual pain causes after different types of surgery evaluated throughout the 18 month period of follow-up are presented in Table 3. According to these results, it is possible to conclude that each group has distinctive features in regards to the structure of residual pain syndrome sources.

Group 1

This group can be distinguished by the significant rate of epidural scar formation associated with radicular pain (verified in 8 cases – 12.3%), the significant rate of myofascial pain which was identified in 17 cases (26.1%), and the high rate of facet joint pain (verified in 15 cases – 23.1%). It should be mentioned that in 16 cases (24.6%) there was a combination of pain sources: the combination of epidural fibrosis and segment instability was verified in one case; the combination of epidural fibrosis and myofascial pain in 7 cases; epidural fibrosis and facet joint pain in one case; and a the combination of myofascial pain and facet joint pain in 7 cases.

Group 2

In this group, the rate of myofascial pain was relatively low (6.5% - 3 cases); however, the rate of facet joint pain was significant despite the minimal surgical aggression. This source of pain was verified in 11 cases (16.9%).

Table 3. *The rates of different causes of pain syndromes after surgical nerve root decompression directly or indirectly related to the applied surgery.*

	Recurrent Disc Herniation or Retained Fragment	Epidural Scar Formation	Instability of Vertebral Segment	Facet Joint Pain	Myofascial Pain
Group 1 n=65	3 (4.6%)	8 (12.3%)	2 (3.1%)	15 (23.1%)	17 (26.1%)
Group 2 n=46	4 (8.7%)	0 (0%)	3 (6.5%)	11 (16.9%)	3 (6.5%)
Group 3 n=27	17 (63.0%)	0 (0%)	0 (0%)	6 (22.2%)	2 (7.4%)

Note: Cases with the onset of pain syndromes irrelevant to the applied surgery were excluded from the analysis.

Group 3

The specificity of this group was the high rate of unresolved nerve root compression or recurrent disc herniation (verified in 17 cases – 63.0%), facet joint pain was determined in 6 cases (22.2%), myofascial pain in 2 cases (7.4%), the combination of facet joint pain and myofascial pain was diagnosed in 2 cases.

Comparing these groups of patients, it is possible to conclude that Group 1 differs from Group 2 by a significant rate of epidural scar formation ($P = 0.0199$) and by a significantly higher rate of myofascial pain presentation (P = 0.0110), however no difference in the rate of facet joint pain was found in these 2 groups ($P = 0.9988$).

Group 3 can be distinguished from Group 1 and Group 2 by the high rate of recurrent or unresolved nerve root compression ($P < 0.0001$ in both cases), the prognostic value was confirmed by significant logistic regression models.

Group 1 versus Group 3, parameters of the regression model: B0 = –5.6723; 95% CI (–9.0678; –4.1076), $P < 0.0001$. Odds ratio = 35.1333; 95% CI (8.5159; 144.7458). Goodness-of-fit $\chi 2 = 36.432$, $P < 0.0001$.

Group 2 versus Group 3, parameters of the regression model: B0 = -5.2334; 95% CI (-7.46724; -2.999517), $P < 0.0001$. Odds ratio = 17.85; 95% CI (4.806283; 66.2929). Goodness-of-fit $\chi 2 = 24.833$, $P < 0.0001$.

Analyzing the difference in the myofascial pain rate observed in Groups 1 and 2, it is possible to conclude that this cause of pain syndrome is associated with a more aggressive intervention. Estimated parameters of logistic regression model for myofascial pain difference:

B0 = -4.287188; 95% CI (-6.719846; -1.85453), $P = 0.0007$. Odds ratio = 5.0764; 95% CI (1.3710; 18.8026). Goodness-of-fit $\chi 2 = 7.8241$, $P = 0.0052$.

Different types of causes of the persistent pain syndromes can be illustrated by the following cases.

Case 1

Before the intervention, this participant (Group 2) presented a typical radicular pain pattern corresponding to the L5 autonomous zone of innervation. MRI tomography diagnosed a protrusion on the level L4-5 and also signs of spondyloarthrosis were evident (Fig.1). After nerve nucleoplasty, there was more than a 50-point decrease in VAS and ODI scores. The residual pain syndrome was mostly axial and there was no evidence of unresolved nerve root compression. Control MRI tomograms showed a decrease in disc protrusion size after nucleoplasty (Fig. 2). Facet joint pain was confirmed by diagnostic blocks and this residual pain syndrome in this case does not illustrate the inability of nucleoplasty to provide total pain relief because nerve root compression was resolved.

Fig. 1. *Case 1 MRI before nucleoplasty.*

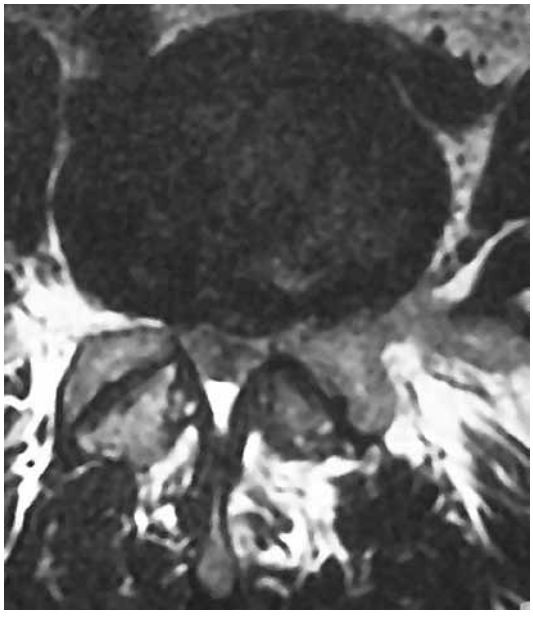

Fig. 2. *Case 1 MRI after nucleoplasty.*

Case 2

This participant presented a typical compressive radicular pain pattern at L5 and disc extrusion was diagnosed on the level L4-5. (Fig. 3 represents MR tomograms one month before the intervention). After microdiscectomy, total pain relief was achieved. However, after 5 months passed, pain recommenced. Pain was mostly axial with irradiation to the buttock and posterior hip areas. Control MR tomograms showed only a significant progression of the spondyloarthrosis (Fig. 4 represents MR tomograms 6 months after the intervention) and facet joint pain was confirmed by the results of diagnostic facet joint blocks. In this case disc extrusion formation and consequent microdiscectomy resulted in a disc space narrowing, finally resulting in an apparent increase in load on the facet joints; thereafter, the progression of the spondyloarthrosis is expected.

Case 3

This participant (Group 1) presented a severe radicular pain and a large disc sequester was diagnosed by the MR tomograms at the level L5-S1. Figs. 5 and 6 represent MR tomograms before the intervention. In

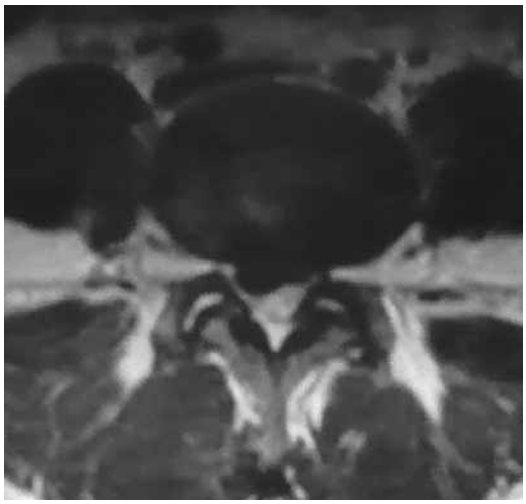

Fig. 3. *Case 2 MRI before the microdiscectomy.*

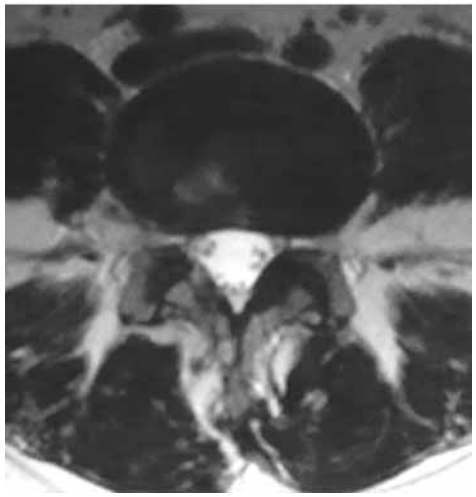

Fig. 4. *Case 2 MRI 6 months after the microdiscectomy.*

Fig. 5. *Case 3 MRI before the microdiscetomy.*

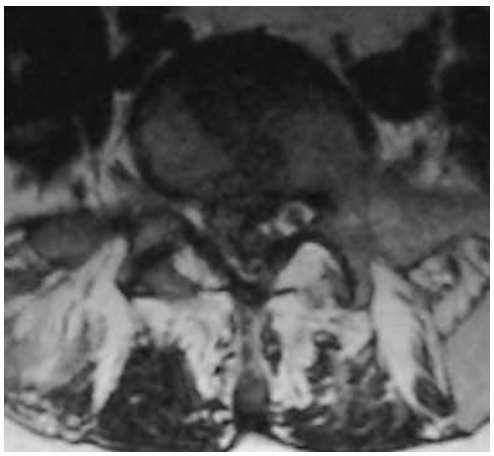

Fig. 6. *Case 3 MRI before the microscectomy*

this case, microdiscectomy was applied and the result was unsatisfactory because of the epidural fibrosis formation and progression of the degenerative changes resulting in a retrospondylolisthesis. Figures. 7 and 8 represents MR tomograms 4 months after microdiscectomy. In this situation, microdiscectomy was insufficient to achieve total pain relief and segment fusion was required. However, this case mostly illustrates the biomechanical disadvantage of the intervention.

Case 4

As mentioned above, some cases with pain presentation after surgery were excluded from the analysis. This case illustrates the type of pain syndrome not related to the applied type of surgery and thereafter excluded from the analysis. This participant presented a typical radicular S1 pain pattern and disc extrusion was confirmed by the results of MR tomography (Figs. 9, 10). In this case, microdiscectomy was applied. After

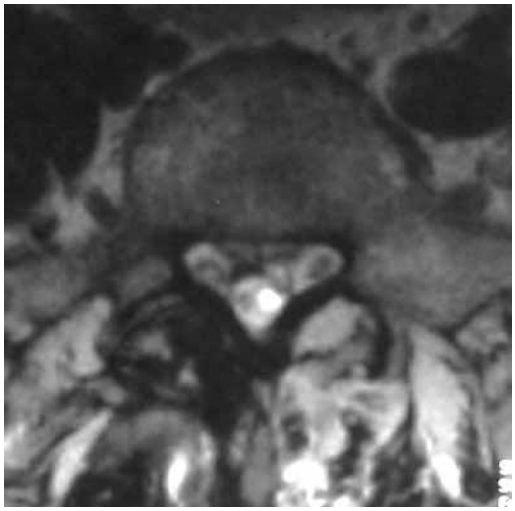

Fig. 7. *Case 3 MRI after microdiscectomy.*

Fig. 8. *Case 3 MRI after microdiscectomy.*

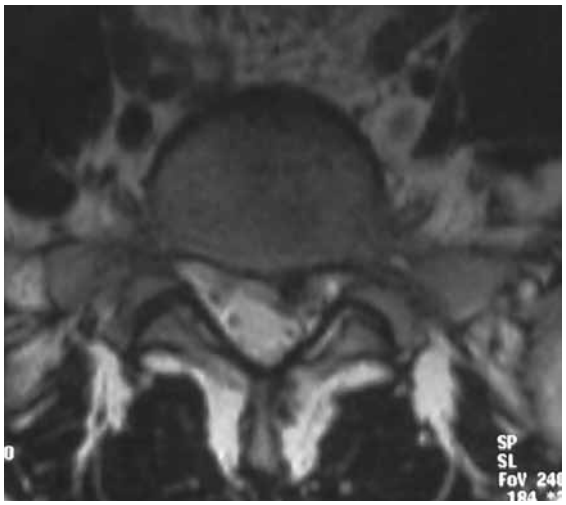

Fig. 9. *Case 4 MRI before microdiscectomy.*

Fig. 10. *Case 4 MRI before microdiscectomy.*

12 months had passed, pain recommenced; however, it was associated with disc degeneration on the adjacent level (Fig. 11). In this case, the recurrent pain syndrome was irrelevant in regards to the applied surgery. Those types of cases were excluded from the presented analysesin order to avoid bias.

Fig. 11. *Case 4 MRI one year after microdiscectomy.*

Discussion

Nucleoplasty applying coblation technology has been widely introduced into clinical practice since 2000; the reported rate of clinically significant results were scattered from 56% to 88%. In all cases the conclusions concerning the efficacy of the applied technologies were based on the analysis of pain-associated numeric scores dynamics (VAS, ODI) and none of the manuscripts provided the explanation for the partial results and failures. Finally, it is impossible to explain such a wide range of reported clinically significant results (55-57,60-62). Even if an analysis of total pain relief and clinically significant results is performed, it is impossible to figure out the reason for the observed differences; in other words, whether it was a result of an unaccounted for factor of the groups' inequality or whether an unfavorable prognostic factor was present in some studies.

In studying the efficacy of the applied technologies, first of all it is necessary to define if the applied intervention is capable of providing stable nerve root decompression in the particular cases studied. The results of our study show that nucleoplasty, being effective in cases of contained disc herniation, failed to provide stable nerve root decompression in the majority of cases when nerve root compression was caused by uncontained disc herniation (disc extrusion), while the results of microdiscectomy in the same situation were considerably better despite the higher invasiveness and biomechanical disadvantages. By analyzing the rates of cases when unresolved or recurred nerve root compression was present, it is possible to make a valid conclusion that total annulus disruption is a limitation for the nucleoplasty indication because of the inability to provide stable nerve root decompression and not because of any other factors. This type of analysis is closely related to the analysis of the clinically significant results rate and has the advantages of comparing with analysis based on the pain related numeric scores dynamics (ODI, VAS), especially in case when a considerable number of different interventions were applied during the follow-up period to manage the residual pain. The analysis based on pain related scores dynamics (VAS and ODI) represents the agglomerative analysis of specific and nonspecific factors influence thereafter the statistical significance of observed effects could be decreased. For example, when the ability of the applied intervention to provide stable nerve root decompression was tested, the estimated regression models were of a higher statistical significance than those estimated analyzing the rates of clinically significant results based on VAS and ODI scores dynamics.

The next category of reasons for pain syndromes after surgical nerve root decompression is related to tissue damage during the intervention. However, the frequency of this kind of pain source illustrates mainly the technical disadvantage of the applied type of surgery. Despite tissue damage being minimized during microdiscectomy and absolute hemostasis being achieved, a considerable rate of radicular pain associated with fibrosis in the epidural space was detected after open surgery. Myofascial pain is known to be caused by multiple factors 63,64) and the results of different studies have supported the hypothesis that myofascial pain may contribute to failed back surgery syndrome (65,66). According to the results of our study, the higher rate of myofascial pain was estimated in the group of patients treated with microdiscectomy and the association with a more aggressive type of surgery was proved by the re-

gression analysis. It is evident that in order to diminish the rate of pain syndromes associated with tissue damage, surgical strategies should be optimized choosing the less invasive intervention among those applicable in a particular case. Even though being generally discouraged to apply more aggressive surgery, the situations should be clearly defined when despite the obvious disadvantages, open surgery procedures are more effective than minimally invasive ones, thereby justifying the rational guidelines among the different technologies.

The third category of persistent pain syndromes is related to the naturally determined disease development; among them are facet joint pain, stenosis, and segment instability. It was proved that those degenerative changes can develop regardless of the type of surgery (20,39,44,46,48,49). Because of the minimal number of cases with clinical presentation of stenosis and segment instability after surgery, the rates of these pain sources were not analyzed. In contrast, the rate of facet joint pain was considerable; however, it has been reported that the higher frequency of facet joint pain has no association with previously applied lumbar surgery: while the overall prevalence of facet joint pain achieves 31% with a 95% CI of 28%-33%, the rate of this source of pain after lumbar surgery was 16% with a 95% CI of 9-23% (20,21,25,58). Also, it was reported that there was no relation of the facet joint pain rate and a number of previous surgeries (20). Even though the higher frequency of facet joint pain was expected in the group treated with microdiscectomy because of more significant loss of disc height, no relationship of this pain source rate to the applied type of surgery was found. Despite evidence that this category of pain sources has a limited specificity in regards to the applied surgery, detailed analysis could provide significant information because rapid progression of degenerative changes is highly associated with altered biomechanics (67,68). Finally, this analysis may point out indirectly the biomechanical disadvantages of surgical interventions (69,73).

Studying the efficacy of different interventions, it is necessary to analize the reasons for failures and partial results in order to explain the observed effects adn finally to understand better the efficacy of applied technology. This information could be helpful to elaborate the optimal surgical strategies, and this analysis may help to discover biomechanical and technical limitations. and Their disadvantages could disclose other factors which could impact the results. Finally, the ability to identify the main and the secondary sources of pain makes possible the application of different minimally invasive interventions, supplementing those applied previously for nerve root decompression, which may improve the condition of patients presenting with failed back surgery syndrome.

This study is limited because of the groups' disproportionate, loss of patients to follow-up, and that it is nonrandomized. Also, this study could be criticized because the dynamics of numeric scores were not provided; however, the main aim was to show different types of analyses of technology efficacy and the significance of the additional statistical analysis focused on the evaluation of causes of failures and partial results comparing different types of surgical interventions.

Conclusion

The results of our study show that the analysis of the reasons for failed back surgery syndrome and partial effects of interventions applied for nerve root decompression might help to better understand the efficacy of the interventions and could be helpful for improving surgical strategies. However, the conclusion could be limited because not all sources of residual pain illustrate the efficacy of the applied technology. In the majority of cases, the cause of the residual or recurrent pain can be identified, and this may open new possibilities to improve the condition of patients presenting with failed back surgery syndrome.

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