

Outcome following lumbar disc surgery: the role of fibrosis

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Abstract

Background Failed-back surgery syndrome remains a challenge for spinal surgeons. It can be related to several causes, including poor surgical indication, misdiagnosis, surgical technique failure, spondilodiscitis and fibrosis. Fibrosis has been associated with a poorer outcome in lumbar disc surgery, although its role in the generation of symptoms is not yet clear. In this study, the authors have analyzed any possible correlation between the clinical outcome and the degree of fibrosis.

Method Forty consecutive patients were enrolled in a prospective study. All of them had operations in the lower lumbar disc in a single level for the first time. Three months after the operation they were submitted to clinical outcome evaluations and questionnaires, including Numeric Pain Rating scales (NPR) for lumbar and leg pain, the McGill Pain Questionnaire, The Quebec Back Pain Disability scale (QBPD) and Straight Leg Raising test. These data were correlated with the degree of fibrosis as revealed by Magnetic Resonance Imaging (MRI).

Findings After 3 months, the NPR values for lumbar and leg pain ranged from 0 to 8 (mean 2.32 and 1.67 respectively). The values of the post-operative QBPD scale ranged from 1 to 71 (mean 25.9). Every patient showed a varied degree of fibrosis on MRI. However, statistical analysis depicted no significant correlation between fibrosis and a poorer clinical outcome for pain and disability.

Conclusions The authors found no correlation between excessive fibrosis with lumbar and leg pain, disability or straight leg resistance. The role of fibrosis in the generation of symptoms in patients who have had lumbar disc surgery should be reevaluated.

Keywords Lumbar disc · Fibrosis · Surgery · Magnetic resonance imaging · Failed-back

Introduction

Lumbar disc herniation (LDH) is a common medical problem [23, 31, 113, 127], characterized by the displacement of the nucleus pulposus, usually related to disc degeneration [2, 14, 18, 35, 41, 43, 47, 63, 64, 83, 109, 120]. The compression of neural structures, as well as a local inflammatory reaction can cause lumbar and leg pain as well as other neurological symptoms [6, 8, 9, 27, 33, 59, 86, 88, 107, 112, 114, 129, 130].

Every year, many patients undergo operations for LDH worldwide [4, 5, 19]. Although most have a good post-operative outcome [11, 50], a significant number of them can continue to have lumbar and leg pain as well as disability. These patients, identified as having failed-back surgery syndrome [80], often are considered a challenge to the medical staff [75]. This is related to many different factors, such as misdiagnosis, surgical technique failures,

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new disc prolapses, fibrosis, instability, facet syndrome and spondylodiscitis [44, 52, 65]. Psychological and occupational problems are also important prognostic factors [24, 29, 30, 48, 71, 92, 94, 105, 115, 121].

Namely, fibrosis has been implicated as the generator of pain in 8–24% of cases [1, 40, 68], but its real role in provoking symptoms has yet to be completely understood [98]. While many clinical studies show a positive correlation between fibrosis and pain, many others fail to prove any such a link [76, 77, 102]. Despite the importance of this topic, there has been no extensive analysis thus far on the role of fibrosis.

Our study was prospectively designed with 40 consecutive patients who were to undergo low lumbar disc surgery for the first time. Three months after surgery, clinical and image data were compared and analyzed. Our primary goal was to confirm any possible correlation between fibrosis and new or residual symptoms.

Methods and materials

Casuistic

An initial group of 48 patients were investigated. Of these, seven had been excluded due to incomplete information (mostly did not have an MRI at the study interval). One had a possible infection discitis and have been excluded.

A prospective study was then conducted with 40 consecutive patients undergoing low lumbar disc surgery in a single level, using a microsurgical technique at the Instituto de Neurologia de Curitiba, Brazil. Only those with complete data were analyzed.

The following cases were excluded: (1) patients under 18 years old; (2) any surgeries other than disc herniations (such as spondylolisthesis or spinal canal stenosis); (3) patients those who needed instrumentation; (4) extreme lateral herniations needing a different surgical approach; (5) recurrence of pain due to anatomical conditions, such as a new compressive disc herniation or spondylodiscitis; (6) patients refusing to undergo a complete protocol; (7) patients who were pregnant and (8) those who had psychiatric disorders.

Surgical technique

A similar microsurgical technique was used in every case. A midline posterior incision of about 4–6 cm was made, followed by the opening and retracting of the lumbar aponeurosis and the muscles. After complete exposure of the interspace, a microsurgical partial hemilaminectomy was performed and the ligamentum flavum was opened enough to expose the dural sac, the nerve root and the entire disc herniation. The disc was then removed. No foreign

body, including cotton patches, hemostatic materials or antifibrotic substances was used.

Patients were started on physical therapy the first day after surgery, including gradual mobilization and posture orientation.

Clinical evaluation

A thorough clinical evaluation was completed in two stages:

1. The day before surgery, identification data was obtained, as was a neurological examination. The patient rated his/her lumbar and leg pain from 0 to 10 by using Numeric Pain Rating scale (NPR) zero being no pain and 10 the worst pain, and completed the McGill Pain Questionnaire (McGPQ) and The Quebec Back Pain Disability scale (QBPD), both versions in Portuguese [26, 53, 66, 79, 93, 118].
2. Three months after the surgery, patients underwent a new evaluation, including the clinical outcome. Patients rated both their lumbar and leg pain on the NPR scale, and completed a post-operative McGPQ and QBPD scale. At this time, the Straight Leg Raising test (SLR) was performed and the angle of raised leg at which the patient began to experience pain was recorded [99].

McGPQ is a well-known scale for the evaluation of the qualitative aspects of pain. It consists of 20 word descriptors in sensory, affective, evaluative and miscellaneous categories. In this study, the authors analyzed both the number of descriptors and the total values.

The QBPD is a 20-item questionnaire, evaluating physical restrictions due to back problems. The authors have analyzed the sum of the 20 items.

Image acquisition

Every patient underwent Magnetic Resonance Imaging (MRI) 3 months after surgery. The images were acquired by a Siemens 1.5-T apparatus, using the following protocol: (1) sagittal T_1 -weighted Fast Spin Echo (FSE); (2) sagittal T_2 -FSE; (3) axial T_1 -FSE; (4) axial T_2 -FSE; (5) axial T_1 -FSE after intravenous contrast and a (6) sagittal T_1 -FSE after intravenous contrast.

Contrast bolus (Gadolinium) was used in 0.1 mmol/kg doses on each patient and the images were acquired not more than 10 min later.

The images were analyzed by three independent neuro-radiologists. Their primary goals were to confirm the existence of a soft tissue characteristic as peridural fibrosis and to measure the size.

Evaluation of the degree of fibrosis was done with contrast phased MRIs. Axial T_1 images were obtained at the

intervertebral space plus one level above and below. Each of these three images was then divided into four quadrants, with two perpendicular lines through the middle of the spinal canal. The extent of this fibrosis was based on criteria defined by Ross, in 1998 [103]. In each quadrant, the fibrosis was graded on a scale from 0 to 4, in accordance with the following rule: grade 0, no fibrosis; grade 1, fibrosis $\leq 25\%$; grade 2, $>25\%$ but $\leq 50\%$; grade 3, $>50\%$ but $\leq 75\%$; grade 4, $>75\%$ fibrosis. The Fibrosis Index (FI) was achieved by the addition of these three values (Fig. 1).

The authors also evaluated additional values such as the degree of fibrosis from the operated side only and from the central axial image (not including images above or below the area).

Statistical analysis

In analyzing the correlation between fibrosis and pain, the authors used the Mann–Whitney non-parametric test. In evaluating the correlation between quantitative values, the Spearman's correlation coefficient was applied. Finally, the Kruskal–Wallis non-parametric test was used in the statistical analysis of the level operated. In every case, $p < 0.05$ characterized statistical significance.

Results

Of the 40 patients enrolled in this study, 25 were men (62.5%) and 15 were women (37.5%), with ages ranging between 23 and 68 (mean 44.2). A slightly higher proportion of patients were in the 30–39 age group. Thirty-four patients (85%) were Caucasian.

Before surgery, three patients had no back pain (NPR=0). Of the remaining 37 patients, the back pain started from 10 days to 20 years before surgery (mean 4 years 8 months). Leg pain was described as commencing 25 days to 20 years before surgery (mean 1 year 9 months).

Leg pain was on the right side in 16 patients (40%) and on the left side in 34 patients (60%). There was no significant bilateral pain in any patient. A majority of them (24 cases—60%), were operated at the L5–S1 level, followed by 12 (30%) at the L4–L5 and 4 (10%) at the L3–L4 level.

Pre-operatively, neurological examinations disclosed hypoesthesia in 20 patients (50%), motor dysfunction in 10 patients (25%) and reflex abnormalities in 11 patients (27.5%).

Lumbar and leg pain

Lumbar pain before surgery, according to the NPR scale, ranged from 0 to 10 (mean 5.65) and after surgery, it ranged from 0 to 8 (mean 2.32). Most patients had a better NPR score after surgery, but in four patients the rate was the same as pre-operatively and three experienced a slight increase in their scores.

Leg pain before the operation was rated from 0 to 10 (mean 6.42). In the post-operative evaluation, leg pain ranged from 0 to 8 (mean 1.67). In two patients, the NPR values were roughly unchanged, while four patients experienced an increase in pain.

The McGill pain questionnaire (McGPQ)

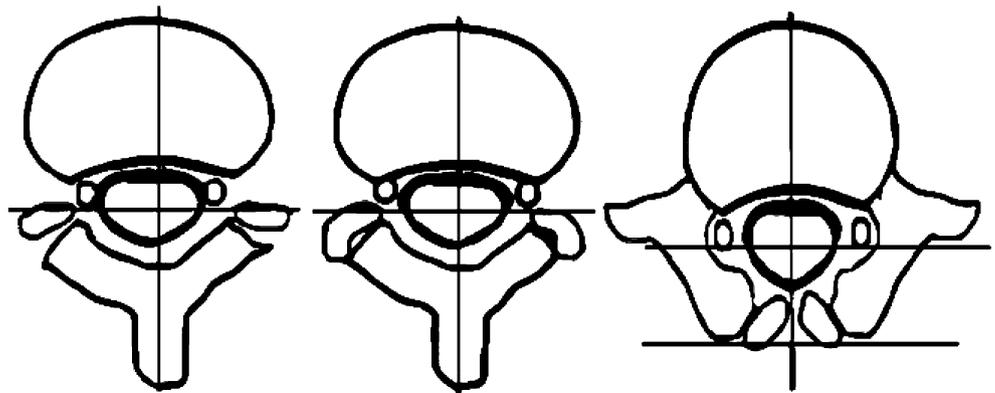
The number of word descriptors in the pre-operative evaluation ranged from 7 to 20 (mean 15.6) with the sum ranging from 12 to 59 (mean 35.5).

After surgery, the number of descriptors ranged from 0 to 20 (mean 6.72), while the sum ranged from 0 to 40 (mean 10.9).

The Quebec back pain disability scale (QBPD)

The physical disability due to back pain was analyzed by QBPD scale. Before surgery, values ranged from 14 to 96 (mean 56.2) and during the post-operative period, the range was from 1 to 71 (mean 25.9).

Fig. 1 Three consecutive MRI images. The central image passes through the operated disc space, while the others pass above and behind it. Each image was divided in four quadrants, with two perpendicular lines centered at the middle of the spinal canal. In each quadrant the degree of fibrosis was measured. Based on Ross et al. [103]



Straight leg raising test (SLR)

The SLR test, which measures the angle of the raised leg at which the patient experiences pain, was administered only in the post-operative period. In 13 patients, the measurement was comparable bilaterally. In one case, the measurement on the non-affected side was worse than on the operated side. In all other cases (26), there was a worse measurement on the operated side (i.e. pain at less motion). Ipsilateral to the surgery, the values ranged from 45° to 90° (medium 68.5°). Contralaterally, the values were from 30° to 90° (medium 73.9°).

Fibrosis index (FI)

The sum of fibrosis in the four quadrants, in the three consecutive images ranged from 2 to 31 (mean 16)—Table 1. There was no correlation between the degree of fibrosis and the ages of the patients ($p=0.0606$). In addition, no relationship was found between the degree of fibrosis and the gender ($p=0.4722$) nor was there with the levels at which they were operated ($p=0.9521$).

The accepted value of fibrosis in each quadrant was the one in which at least two neuroradiologists rated the same amount of fibrosis which was the case in 39 of the 40 patients. In only one patient, the amount of fibrosis was rated as the sum of the three scores divided by three.

Correlation between the FI and outcome

Different analysis showed no statistically significant correlation between the FI and the clinical outcome (Table 2). The intensity of fibrosis was not related to higher levels of lumbar pain ($p=0.1208$) or to higher levels of leg pain ($p=0.2997$).

The McGPQ showed no correlation to the FI, neither in the number of descriptors ($p=0.8956$) nor in their sum ($p=0.9510$).

The SLR test when applied either ipsilaterally or contralaterally showed no statistical significance to the FI ($p=0.8664$ and $p=0.7905$ respectively).

Further, seven patients with higher lumbar pain scores were analyzed separately. This group of seven had a mean FI of 17.3 (versus the FI average of 16 for all patients). Although this score was slightly higher than average, there was no statistical significance.

The FI was even lower than the average (14.2) when only patients with a higher level of leg pain were analyzed (a total of five patients with the higher scores on leg NPR scale).

When only the eight patients with high scores in the QBPD scale were analyzed, the FI was slightly higher than average (16.37), with no statistical significance.

Conversely, when patients with higher levels of fibrosis were analyzed (a total of eight patients with higher FI), only two of them had lumbar pain NPR values above 3 (mean 2.5), and only one had leg pain NPR values above 3 (mean 1.37). The QBPD scale values for this group was 26.37 (versus a 25.9 total average). In every case, there was no statistical significance.

Discussion

LDHs are commonly diagnosed as causes of lumbar and leg pain in adults [15, 16, 22, 39, 72, 89]. They cause pain, physical disability and economic losses worldwide [108, 116]. Although most patients get better without surgery, many others require spinal procedures.

After lumbar disc surgery, some patients may complain of persistent pain, either in the lumbar or leg region [10, 20, 37, 38, 56, 62, 67, 73, 87, 90, 96, 119, 125]. Many factors may be related to this issue [74, 95, 97, 117]. Epidural fibrosis has been described as a main factor in the generation of pain, provoking symptoms in 8–24% of patients operated of LDH [25, 85, 106].

Despite the importance of this topic, little has been studied about the role of fibrosis. Previous publications have raised questions that call for further research in: (a) the mechanisms of the formation of fibrosis; (b) if fibrosis is, in fact, a cause of lumbar or leg pain; (c) how fibrosis provokes pain; (d) the clinical characteristics involved; (e) does it need treatment and; (f) does it need to be prevented.

Despite the relevance of this subject, the few studies conducted either experimental or clinical, were small and controversial and did not entirely answer these questions.

The mechanisms of the formation of fibrosis are not entirely known. Some factors have been linked to this occurrence, such as a larger extension of the laminectomy, a greater paravertebral muscles retraction and the occurrence of hematomas in the surgical bed [12, 69, 84, 110, 111].

Our prospective study on this specific group of patients did not show any correlation between the clinical outcome and the degree of fibrosis. This lack of correlation occurred in all of the values analyzed, including intensity of lumbar and leg pain and the qualitative aspects of pain, as well as any post-operative disability. A high p value was seen in most statistical analysis.

Despite the significant number of patients in our group, a larger population should be used in future studies and could be done ideally in multiple research centers. The use of various centers, however, could cause biases due to varying surgical techniques and different analysis of MRIs. The high cost of MRI exams restricts, somehow, its overuse.

It must be noted that our study included only those patients who had had surgery 3 months earlier. It is well

Table 1 Evaluation of pain and disability before and after surgery as related to peridural fibrosis index in all 40 patients

Number	Before surgery					Fibrosis Index	After surgery						
	LU-NAS	LE-NAS	QBPDS	McGill-ND	McGill-S		LU-NAS	LE-NAS	QBPDS	McGill-ND	McGill-S	SLR-I	SLRC
1	8	9	62	14	27	12	0	0	1	2	3	55	65
2	2	0	61	7	13	6	0	0	13	2	2	80	85
3	5	5	33	7	12	11	5	0	46	11	20	60	65
4	6	10	88	20	54	12	0	0	4	0	0	70	75
5	6	6	14	19	47	23	1	0	12	9	12	60	65
6	3	5	33	16	25	19	0	0	1	0	0	80	80
7	5	6	44	18	50	15	8	8	52	20	29	55	60
8	8	5	53	7	14	24	1	2	34	3	3	75	65
9	5	5	34	19	43	13	2	1	34	11	16	75	75
10	8	4	77	14	28	11	1	0	2	1	1	75	75
11	0	8	78	16	38	10	4	3	31	8	19	35	65
12	5	5	87	13	34	21	5	3	38	2	3	60	75
13	4	1	29	17	32	31	2	0	8	1	2	60	60
14	2	1	32	8	18	14	0	0	8	3	4	75	75
15	10	7	68	16	39	16	5	0	57	12	21	45	60
16	5	10	32	19	43	23	1	0	6	1	1	65	75
17	5	9	53	20	47	24	2	2	36	2	3	70	70
18	9	8	58	19	57	18	1	1	37	8	12	60	70
19	5	6	51	15	28	9	0	3	19	13	22	80	80
20	6	9	62	13	30	22	2	2	15	4	6	90	90
21	9	4	48	20	48	16	1	1	7	3	5	60	65
22	3	10	82	19	47	20	2	3	53	13	21	60	80
23	9	9	74	19	30	13	0	6	58	9	15	65	65
24	0	10	86	17	43	11	2	3	18	11	14	60	70
25	5	6	96	18	48	11	3	0	56	11	21	85	80
26	4	8	47	16	32	15	3	0	19	3	6	70	85
27	5	10	78	20	59	15	1	1	22	4	6	55	80
28	4	6	42	13	27	13	0	0	6	0	0	70	70
29	6	0	48	17	36	19	5	3	35	18	40	78	90
30	8	9	51	20	42	19	1	3	46	16	25	90	90
31	4	9	68	20	38	8	3	5	19	10	12	48	78
32	7	4	41	15	33	19	7	7	40	14	18	60	65
33	6	0	22	12	27	2	3	0	26	3	7	85	85
34	10	10	83	20	50	13	1	0	12	3	3	70	30
35	2	8	68	7	16	6	1	0	12	2	2	60	65
36	5	9	34	14	27	23	5	0	29	4	5	70	75
37	5	10	71	14	21	26	6	5	71	18	34	65	65
38	9	7	67	15	43	18	0	0	14	0	0	70	75
39	9	9	67	20	55	20	5	3	28	4	8	75	85
40	9	0	25	12	21	21.5	4	2	13	10	16	75	85

LU-NAS lumbar pain numeric analogic scale, *LE-NAS* leg pain numeric analogic scale, *QBPDS* the Quebec pain disability scale, *McGill-ND* McGill pain inventory—numbers of descriptors, *McGILL-S* McGill pain inventory—sum, *SLR-I* angle needed to produce pain in straight leg raising test ipsilaterally, *EPE-C* angle needed to produce pain in straight leg raising test contralaterally

known that this period of time corresponds to the formation of a mature scar. Fibrosis can, however, decrease after 3 months and the clinical outcome can change, i.e. according to our study, it cannot be stated that this lack of correlation occurs in later phases of recovery. Hakkinen et al. [54], however, concluded that the early outcome seems to be a good indicator of the long-term outcome in their

analysis of patients who had had disc operations when comparing their outcome after 2 months and 1 year after surgery.

Annertz et al. [7], in 1995, analyzed the MRIs of 16 patients who had previously had lumbar disc surgery in one level. Eight of those patients were symptomatic enough to undergo a second operation, the other eight were asymp-

Table 2 Correlation between fibrosis and outcome scales

	<i>n</i>	Correlation coefficient	<i>p</i> value
Fibrosis×QBPD	40	0.1482	0.3613
Fibrosis×McGill-ND	40	0.0214	0.8956
Fibrosis×McGill-S	40	-0.0100	0.9510
Fibrosis×SLR-I	40	0.0275	0.8664
Fibrosis×SLR-C	40	-0.0434	0.7905

*QBPD*S Quebec back pain disability scale, *McGill-ND* number of descriptors in McGill pain questionnaire, *McGill-S* sum of all descriptors in McGill pain questionnaire, *SLR-I* straight leg raising angle enough to produce pain ipsilaterally to the operated side. *SLR-C* straight leg raising angle enough to produce pain contralaterally to the operated side

tomatic. The study did not show a difference between the two groups in relation to the degree of fibrosis, mass effect, or radicular and dural involvement by the scar tissue.

Coskun et al. [28], in 2000, analyzed 27 patients who had undergone surgery on a lumbar disc herniation in one level. All operations were done by the same neurosurgeon. The authors looked for any possible relationship between the degree of fibrosis (as seen by MRI) with the intensity of pain and disability. They found that there was no difference between those with less or more fibrosis in the evaluation of factors such as the intensity of pain (as measured by the NPR scale) and disability as measured by Oswestry scale [36]. Conversely, they observed a positive correlation between personality abnormalities (using the Minnesota Multiphasic Personality Inventory), with a worse clinical outcome. The authors concluded that epidural fibrosis should be considered a radiologic finding independent of the clinical outcome.

Vogelsand et al. [126], in 1999, analyzed retrospectively 53 patients who had LDH in one level and who had persistent pain. They were divided into two groups: 27 cases with radicular pain and 26 cases with non-radicular pain. Fibrosis was analyzed by MRI. The authors concluded that there was no difference in the degree of fibrosis in either group. They also found that there was no difference in any motor and sensory changes in either group.

Ross et al., in 1996 [3], published the result of a prospective study of patients from nine European centers. They analyzed the correlation between the degree of fibrosis in the four quadrants (varying of 0 to 4 in each quadrant) and the persistence of pain as assessed by the Visual Analogic Scale (VAS). Patients with a lesser degree of fibrosis presented significant pain (VAS>4) in 5.3% of the cases, whereas those with intense fibrosis presented significant pain in 16.7% of the cases. Despite the fact that this study showed that the patients with more intense fibrosis were 3.2 times more likely to present pain, the majority of patients with intense fibrosis had little or no symptom. The study

concluded that a straight correlation exists between the degree of fibrosis and the recurrence of radicular pain.

One of the most common tools used to prevent fibrosis has been an antiadhesion gel (Adcon-L[®], Gliatech Inc). It's composed of gelatin and a polyglycan ester in saline. Some animal studies showed a significant reduction in post-operative fibrosis in dogs [34] and in mice [91]. Humans studies were controversial.

Maroon et al. [76], in 1999, described the results of a multi-center randomized analysis of 267 patients who underwent lumbar disc surgery for the first time. The study consisted of 141 patients in a control group, with the other 126 receiving ADCON-L[®] in the epidural space at the end of the surgery. The authors verified that the treated group presented a lesser degree of fibrosis in the MRI. The patients with a higher level of fibrosis had more frequent and more debilitating lumbar pain.

Ganzer et al. [46], in 2003, randomly administered Adcon-L[®] to 92 patients. In follow-up evaluations, they found no differences between those who received Adcon-L[®] to those who did not, either in the clinical evaluation, or in the degree of fibrosis in the MRI.

Richter et al. [100], in 2001, described a similar result in a German multi-center study, analyzing 357 patients, of which 180 patients used ADCON-L[®], and 177 were in the control group. They found no significant difference between the two groups in three follow-up evaluations. However, MRIs of 189 of the patients showed a small difference between the groups, where the degree of fibrosis was mildly smaller in the group where the anti-adhesion gel was used.

Others methods recommended to avoid fibrosis are: the placement of fat in the epidural space, dura substitutes, synthetic foams, application of hyaluronidase, mitomycin-C and post-operative radiotherapy [17, 21, 45, 49, 51, 55, 70].

Our study showed that MRI is appropriate for the evaluation of disc prolapses and fibrosis, as supported by other authors [13, 32, 57, 58, 60, 61, 78, 81, 82, 101, 103, 104, 122–124]. In almost every case, there was a similarity between the results of three independent neuroradiologists.

In our study, the majority of the patients were young adults and, a majority of the cases experienced superior results, which can be confirmed by the significant reduction of NPR scale in the leg and lumbar.

Our study clearly demonstrated a lack of correlation between fibrosis and radicular pain. Lumbar pain, despite being slightly higher in the fibrotic group, did not reach statistical significance. In our sample, there was no difference between the degree of fibrosis in different genders or at different operated levels.

Our analysis shows that epidural fibrosis seems to be a physiological finding and should not be considered as a cause of pain and disability.

Conclusion

Based on this study, the authors conclude that MRI is adequate to evaluate the degree of fibrosis after surgery for disc herniations and that there is no relationship between epidural fibrosis and the clinical outcome. Therefore, fibrosis seems to be considered a physiologic phenomena and its role in the generation of pain and disability should be reevaluated.

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