Frequency and clinical meaning of long-term degenerative changes after lumbar discectomy visualized on imaging tests

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Abstract The aim of this retrospective controlled study was to evaluate radiographic degeneration in the lumbar spine of patients who had undergone lumbar discectomy minimum 21 years earlier and its clinical meaning. Indeed, no previous investigation on degenerative changes occurring after lumbar discectomy with a comparable long follow-up has been published. The study participants consisted of 50 patients who had undergone discectomy for lumbar disc herniation. The mean length of follow-up was 25.3 ± 3.0 years. Patients were assessed by Short Form-36 Health Survey (SF-36), Oswestry Disability Index, and a study-specific questionnaire. Radiographic views of the lumbar spine were obtained from all patients and compared to those of 50 asymptomatic controls. A five-step published classification was used to assess the increasing severity of radiographic changes. CT or MRI scans were also available for 27 patients who had undergone discectomy. Moderate to severe radiographic changes were present in 45 patients (90%) and 34 controls (68%), respectively ($P = 0.013$). The most prevalent MRI/CT changes were loss of disc height (89%), facet joint arthritis (89%), and endplate changes (57%). Thirty-two of 33 subjects (97%) reporting pain during the last 12 months had significant degeneration on their radiographs, and the frequency of changes was

higher with respect to subjects without pain ($P = 0.040$). In conclusion, standard lumbar discectomy frequently leads to long-term degenerative changes on imaging tests. The presence of moderate to severe degeneration is associated with self-reported pain.

Keywords Discectomy · Low back pain · Long term follow-up · Lumbar spine · Radiography · Surgery

Introduction

Patients who had undergone lumbar discectomy many years earlier usually have a satisfactory functional outcome [20, 28, 36] but they often complain of residual low back pain (LBP) [19, 20, 36]. Plain radiography is frequently required in elderly people with LBP [17] because of its low cost and easy availability, although there is not evidence that the routine use of this imaging test is associated with an improvement in the outcome of these patients [7, 17]. Several studies investigated postoperative changes in the lumbar spine of patients who had undergone discectomy for lumbar disc herniation (LDH), visualized on both radiographies and magnetic resonance imaging (MRI) at variable follow-up intervals [3, 11, 16, 19, 26, 28, 33, 36], and these changes have been associated to LBP [16, 36]. As no data on radiographic degenerative changes at minimum of 20 years from surgery is available, it would be of interest to assess whether a previous discectomy may influence these long-term alterations and what is their clinical meaning. Indeed, several degenerative changes in the lumbar spine have been reported as incidental morphological findings on both standard radiographs [34, 35] and MRI scans [5, 14, 15, 29] of asymptomatic subjects. The

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purpose of the present study was to analyse degenerative radiographic, MRI, and computed tomography (CT) changes in patients who had undergone lumbar discectomy a minimum of 21 years previously, comparing their findings with those of asymptomatic subjects. The possible association of these changes with patients' self-reported pain and long-term functional outcome assessed by validated instruments was also investigated.

Materials and methods

Study population

This study represents a radiographic evaluation of 50 patients, being an integral part of a cohort of 448 patients who received standard discectomy for lumbar disc herniation at our institution from 1973 to 1983, and accepted to undergo radiographic examination of their lumbar spine. Long-term clinical results of the whole cohort have been reported elsewhere [20, 22]. The age, gender, levels of herniation, and functional results as assessed by validated tools of participants were not significantly different from that of remnants of the cohort. Patients enrolled fulfilled the following inclusion criteria (1) primary surgery performed using a herniotomy with curettage of the disc space; (2) absence of degenerative changes on preoperative standard radiographs; and (3) no history of lumbar spine trauma. Exclusion criteria were (1) narrowing of the spinal canal at operation; and (2) previous back surgery at the time of primary operation. The age at operation of participants was 37.6 ± 8.5 years (range 13–57) and indications for surgery were (1) severe radiculopathy of at least 6-weeks duration unresponsive to conservative treatment, and (2) signs of neurological deficit. The diagnosis of LDH and its level was assessed on a clinical basis. ONE-level discectomy was carried out in 39 patients (78%) and TWO-level discectomies in 11 (22%). The levels of discectomy were L5–S1 in 22 cases, L4–L5 in 34, and L3–L4 in 5. The mean $\pm$ standard deviation (SD) length of follow-up was 25.3 ± 3.0 years (range 21–32). Radiographic findings in these 50 patients were compared to those of 50 matched asymptomatic non-operated subjects meeting the following inclusion criteria (1) no history of LBP over the last 3 years, (2) no previous diagnostic examination or specialist consultation for LBP, and (3) absence of clinical hip or knee involvement. These unexposed subjects were enrolled in our department among relatives of in-patients, paramedical staff, and patients suffering for trauma of their upper extremities. Main characteristics of patient and unexposed group, along with their matching, are shown in Table 1. All methods as well as the design of the current study were approved by the local Medical Ethics Committee.

Table 1 Characteristics of patients ($n = 50$) and unexposed subjects ($n = 50$)

	Mean $\pm$ SD or N (%)		<i>P</i>
	Patients	Unexposed subjects	
Age $\pm$ SD	63.4 $\pm$ 8.4	64.7 $\pm$ 9.6	0.49
Sex (m:f)	33:17	33:17	1.00
Body mass index (BMI) $\pm$ SD	28.2 $\pm$ 5.7	27.1 $\pm$ 3.4	0.30
Comorbidity (CIRS score) $\pm$ SD	7.3 $\pm$ 6.2	6.5 $\pm$ 3.2	0.42
Educational level			
Illiteracy	5 (10%)	3 (6%)	0.75
Primary school	17 (34%)	21 (42%)	
Secondary school	14 (28%)	12 (24%)	
High school	12 (24%)	10 (20%)	
Graduation	2 (4%)	4 (8%)	
Lifetime workload			
Sedentary work	14 (28%)	14 (28%)	0.74
Light work	27 (54%)	24 (48%)	
Heavy manual work	9 (18%)	12 (24%)	
LBP in relatives	39:11	37:13	0.82

Patients baseline and follow-up data

Pre- and intra-operative patient's data was obtained from a special form which has been used in our department since its foundation. Information on the patient's clinical history as well as the findings on operation always have been gathered on this form according to the same unchanged standardized protocol. On the follow-up assessment, after informed consent was obtained from each, the patients' weight and height were recorded. All the participants then underwent a structured assessment using an expanded outcome set mainly based upon previously published measures and definitions [2, 8, 18, 19, 23] which is summarized in Table 2. Final results of Oswestry Disability Index (ODI) were categorized into groups of increasing functional impairment as follows 0–20% (minimal disability), 20–40% (moderate disability), and more than 41% (severe disability) [19]. Short Form-36 Health Survey (SF-36) results were compared to those obtained in unexposed subjects and to the published normative data [1]; differences of 10 or more points obtained in the study group compared to the normative data were considered a significant variation [31].

Imaging assessment

All patients and unexposed subjects underwent radiographic evaluation by standard anteroposterior, lateral and oblique standing radiographs of the lumbar spine. The severity of radiographic degenerative changes was graded

Table 2 Clinical and imaging assessment

Scale or finding	Purpose	Definitions and details
Clinical, demographic, and functional parameters		
Short Form-36 Health Survey (SF-36)—Italian version [2]	General quality of life	Eight scales: PF physical functioning, RP role physical, BP bodily pain, GH general health, VT vitality, SF social functioning, RE role emotional, MH mental health Two summary measures: PCS physical component summary, MCS mental component summary
Oswestry Disability Index (ODI) [8]	General back function	Percentage of disability [19]: 0–20% minimal, 20–40% moderate, $\geq 41\%$ severe
Cumulative Illness Rating Scale (CIRS) [18]	Comorbidities	Summative score for all independent organ area domains, each scored from 0 (no condition) to 4 (extremely serious condition)
Study-specific questionnaire	Educational level	0 illiteracy, 1 primary school, 2 secondary school, 3 high school, 4 graduation
	Back problems in first degree relatives	Relative had sought medical care for pain, or had pain sufficient to limit daily activities [23]
	Lifetime workload [19]	1 sedentary, 2 light work with some physical activity, 3 heavy manual work
	LBP and/or leg pain in the last 12 months	1 yes, 0 no
	Severity of pain on a 10-step visual analogic scale	≤ 5 Light to moderate, ≥ 6 incapacitating
	Satisfaction with surgery	1 yes, 0 no
	Willingness to undergo the same operation again	1 yes, 0 no
	Reoperations	1 yes, 0 no
Radiographic findings	Time elapsed until reoperation	
	Severity of lumbar degeneration	Grade 0 absence of degenerative changes Grade 1 marginal osteophytes, no disc narrowing or facet joints arthritis; Grade 2 disc space narrowing of equal or less than 33 percent plus marginal osteophytes; Grade 3 disc space narrowing of more than 33 percent plus large marginal osteophytes and hypertrophy of facet joints Grade 4 complete collapse of disc space and/or degenerative spondylolisthesis
Number of degenerated levels		
MRI/CT findings (27 patients)		
Loss of disc height [14]		In comparison with expected height of a hydrated disc at the same level
Disc bulging		
Disc herniation [15]		Disc protrusion or extrusion
Facet joint arthritis [10]		Rim narrowing, subchondral bone sclerosis, or osteophytes
Spondylolisthesis		
Central spinal stenosis [30]		Dural sac cross-sectional area less than 100 mm ²
Modic-type endplate changes [24] (patients with MRI)		Type 1 (edema) or type 2 (fat)

in a five-step scale according to Kambin et al. [16] (Table 2). Radiographic scoring was done by two specifically trained authors, who were unaware of clinical

characteristics of the patients, and the same measurements were repeated twice on two separate days. Cohen's kappa coefficient for interobserver and intraobserver reliability of

scoring was 0.82 and 0.88, respectively. A consensus decision on scores was anyway reached in a final common readout. At the time of the follow-up control, 27 of the 50 patients (52%) had undergone MRI (14 patients), CT (6 patients), or both examinations (7 patients) of their lumbar spine, carried out 22.9 ± 3.5 years (range 14–29) on average from the operation, independently from the current study. No significant differences with respect to the age, gender, or levels of herniation were detected between participants having undergone MRI, CT, or both and the remnants. Single anomalies were evaluated on CT or MRI images according to the literature [10, 14, 15, 24, 30] (Table 2). All scans were examined by two different neuro-radiologists who were unaware of the clinical characteristics of the patients and the assessment was repeated twice on two separate days. The kappa value for repeated measurement of single degenerative findings on MRI and CT scans varied from 0.63 to 0.84 and from 0.62 and 0.90 for interobserver and intraobserver agreement, respectively.

Analysis

Two sample *t* tests, χ^2 test, and Fisher's exact test were used to test the significance of the cross-sectional differences between groups. Univariate and multiple stepwise linear and logistic regression analyses were used to evaluate relationships between explanatory variables and outcomes with continuous and categorical distributions, respectively. In the first step, predictors of degenerative changes on follow-up radiographs were evaluated. Two outcome variables reflecting the presence of moderate to severe degenerative changes (0 severity scale score ≤ 1 ; 1 severity scale score ≥ 2) and their increasing severity (fivestep scale) were used. In the models of multivariate

analysis that used these outcomes, the following explanatory variables were tested: age, sex, body mass index (BMI), lifetime workload (threestep scale), and occurrence of back problems in first degree relatives. To improve the statistical power of the tests, patients and unexposed subjects were considered jointly, adjusting possible relationships by positive history of discectomy. The effect of reoperations and levels of discectomy (one or two) was also evaluated in the patients. Possible influences of these explanatory factors on single MRI/CT degenerative changes were checked in patients who had undergone these diagnostic tests. Thereafter, possible influence of degenerative changes on patients' functional status and pain were assessed. This effect was checked on SF-36 scale scores and summary measures, ODI, and history of back and/or leg pain in the last 12 months. Possible predictors of patients' functionality and pain included in these models were presence or severity of degenerative changes on standard radiographs, number of degenerated levels, occurrence of single MRI/CT anomalies, age, sex, BMI, educational level (fivestep scale), lifetime workload, occurrence of back problems in first degree relatives, and CIRS score. A *P* value of less than 0.05 was considered significant. SPSS software program was used for the database and statistics.

Results

Degenerative changes

Radiographic findings are reported in Table 3. As it can be seen in the table, degenerative changes were more frequent and severe in patients than in unexposed subjects and also showed different distribution over the lumbar spine.

Table 3 Radiographic degenerative changes

		Study group <i>N</i> (%)	Unexposed subjects <i>N</i> (%)	<i>P</i>
Number of involved levels		1.54 ± 0.8	1.82 ± 1.2	0.193
Severity scale	0	2 (4)	5 (10)	0.007
	1	3 (6)	11 (22)	
	2	13 (26)	13 (26)	
	3	29 (58)	13 (26)	
	4	3 (6)	8 (16)	
Severe changes (severity scale ≥ 2)		45 (90)	34 (68)	0.013
Severity score		2.56 ± 0.9	2.16 ± 1.2	0.063
Involved levels	L1–L2	0	6	0.012
	L2–L3	6	15	0.028
	L3–L4	6	20	0.001
	L4–L5	36	25	0.040
	L5–S1	29	23	0.317

Indeed, radiographic degeneration in patients was mainly located in the lower lumbar spine whereas an even distribution of changes was observed in unexposed subjects. Twenty-six patients of 34 (77%) and 20 of 22 (91%) who had undergone discectomy at L4–L5 and L5–S1, respectively, showed degenerative changes at the same level. There was significant association between discectomy at L5–S1 and degenerative changes at this level ($P = 0.010$). No difference in the frequency or severity of degenerative changes was noted in subject who had undergone one- or two-level discectomy.

The summarized prevalence rates of the different MRI and CT findings are shown in Table 4. Modic-type changes were more frequently noted in the aspects of vertebral bodies bordering severely narrowed discs. In 10 of 12 (83%) individuals with Modic-type changes, these anomalies were found in the vertebrae adjacent to the operated disc. Five patients showed multilevel localization. We could not identify any predictor for degenerative changes on MRI or CT scans, but mutual relationship between such changes and a relationship with radiographic parameters were detected. In detail, the loss of disc height was related to radiographic severity score ($P = 0.005$) and the presence of Modic-type changes was associated to central spinal stenosis ($P = 0.007$). Moreover, there was a trend toward an association between central spinal stenosis and the number of levels radiographically degenerated at follow-up ($P = 0.059$), as well as between Modic-type changes and radiographic severity score ($P = 0.055$).

Functional results

The SF-36's PCS and MCS mean scores of these 50 patients were 42.8 ± 13.1 (14–60) and 45.9 ± 9.6 (26–62), respectively, whereas in the 50 unexposed subjects they were 42.8 ± 13.5 (20–63) and 47.1 ± 12.8 (12–68), respectively. No significant difference in both these scores was detected between patients and unexposed subjects

(PCS, $P = 0.996$; MCS, $P = 0.646$). Moreover, both indexes were similar to age-matched norm values (e.g., PCS = 47.7 ± 9.1 ; MCS = 45.4 ± 10.3). Single SF-36 scale scores are reported in Table 5 for male and female patients, in comparison with results in unexposed subjects and age-matched norms. Males scored similarly to both unexposed subjects and norms, whereas females compared similarly with unexposed subjects and negatively with age-matched healthy subjects. The mean value of the ODI in the study group was 17.7 ± 24 (range 0–86). No or minimum disability was reported by 38 patients (76%), moderate disability by 3 (6%), and severe disability by 9 (18%). Thirty-three of 50 patients (66%) reported back and/or leg pain during the past 12 months, and it was judged incapacitating in 14 (28%). Despite the frequent report of pain, the level of satisfaction with the surgery was high. Forty-four patients (88%) were satisfied with the results of surgery and 46 (92%) would have undergone the same procedure again. Nine patients (18%) reported one or more reoperations. The mean time elapsed from primary to revision procedure was 15.3 ± 7.4 years.

Associations between imaging findings and functional parameters

Thirty-two of 33 patients (97%) having had pain during the last 12 months had degenerative changes of equal or more than 2 points of severity on their radiographs, and the frequency of these changes was higher with respect to patients without reported pain ($P = 0.040$). Positive association between pain and these degenerative changes were also found at age-adjusted univariate logistic regression analysis [odds ratio (OR) = 9.8; 95% confidence interval (95% CI) = 1.0–96.7; $P = 0.049$]. When all confounding variables were included in the model of forward stepwise multivariate analysis, the presence of radiographic degeneration was the only variable to show a trend toward an association with pain (OR = 9.9; 95% CI = 0.9–87.8; $P = 0.061$). We did not find association between pain and radiographic scale of degeneration or the number of involved levels. No radiographic finding predicted ODI variations, and there was also a lack of association between the presence or severity of degenerative changes and SF-36 scores. Conversely, the number of radiographically degenerated levels showed positive influence at the univariate age-adjusted regression analysis on the following SF-36 parameters: MCS [coefficient (c) = 3.4; 95% CI = 0.01–6.8; $P = 0.050$], general health scale ($c = 9.3$; 95% CI = 0.4–18.1; $P = 0.041$), mental health scale ($c = 6.3$; 95% CI = 0.2–12.4; $P = 0.042$), and vitality scale ($c = 9.8$; 95% CI = 2.6–16.9; $P = 0.009$). When all explanatory and confounding variables were added in the models of multivariate analysis, these scale scores were no

Table 4 MRI and CT Findings ($n = 27$)

MRI/CT finding		Cases N (%)
Loss of disc height		24 (89)
Disc bulging		9 (33)
Disc extrusion	Operated level	2 (7)
	Different level	2 (7)
Facet joint arthritis		24 (89)
Spondylolisthesis		0
Central spinal stenosis		11 (41)
Modic changes (only patients with MRI)	Normal marrow signal	9 (43)
	Type 1 change	7 (33)
	Type 2 change	5 (24)

Table 5 SF-36 Scale Scores in male ($n = 33$) and female ($n = 17$) patients and unexposed subjects, in comparison with age-matched population norms [1]

SF-36 scale	Males				Females			
	Study group	Unexposed subjects	<i>P</i>	Published norms	Study group	Unexposed subjects	<i>P</i>	Published norms
PF	82.9 ± 23	74.8 ± 31	0.30	83.9 ± 20	44.7 ± 33	47.9 ± 30	0.79	74.8 ± 24
RP	68.9 ± 39	75.0 ± 39	0.57	72.5 ± 33	27.9 ± 40	35.4 ± 42	0.63	72.6 ± 36
BP	72.4 ± 26	72.8 ± 33	0.96	73.6 ± 24	37.3 ± 25	45.5 ± 29	0.43	63.5 ± 27
GH	64.9 ± 19	63.5 ± 28	0.84	61.7 ± 19	34.8 ± 24	39.3 ± 22	0.62	58.6 ± 22
VT	64.2 ± 19	69.8 ± 24	0.37	63.9 ± 19	42.1 ± 18	37.1 ± 21	0.52	54.1 ± 21
SF	81.8 ± 23	85.8 ± 25	0.56	78.4 ± 23	52.2 ± 31	58.3 ± 23	0.55	74.5 ± 22
RE	72.7 ± 39	80.3 ± 39	0.49	73.6 ± 34	33.3 ± 39	44.5 ± 48	0.52	66.1 ± 40
MH	72.3 ± 14	72.4 ± 25	1.00	69.4 ± 18	52.7 ± 16	46.0 ± 20	0.34	57.6 ± 21

PF physical functioning, *RP* role physical, *BP* bodily pain, *GH* general health, *VT* vitality, *SF* social functioning, *RE* role emotional, *MH* mental health

longer positively influenced by the number of degenerated levels, but a trend toward a positive association was found. On the whole, the most important negative predictors of SF-36 scores were a history of back problems in first degree relatives and the CIRS score.

Patients who had undergone MRI and/or CT examination reported worse functional status (ODI = 26.1 vs. 17.8; $P = 0.028$; SF-36 PCS score = 39.2 vs. 47.0; $P = 0.032$) compared to the ones who had not. The only MRI/CT parameter that showed a trend toward an association with pain in the last 12 months was the presence of facet arthritis ($P = 0.088$). Worse functional status and quality of life scores were recorded among individuals with Modic changes, central spinal stenosis, and facet arthritis, but the differences were not significant. No MRI/CT parameter predicted functional outcomes at the linear regression analysis.

Discussion

Discectomy is only a single event in the lifespan of patients with LDH and, as in the general population, LBP and/or leg pain is a frequent complaint in patients who had undergone this operation many years earlier [19, 20, 36]. These patients, often concerned for their previous operation, frequently undergo standard radiography, which is the most usual investigation for back problems in primary care [17], even because of its reassurance value [13]. Therefore, it is noteworthy to assess whether discectomy can affect occurrence and severity of degenerative changes in the lumbar spine and what is their actual clinical meaning, since in this field imaging findings may influence the diagnostic and treatment approach, and subsequently the use of health care resources [13]. In the current study, we

found that radiographic degenerative changes are more frequent and severe in the lumbar spine of patients who had undergone discectomy 25 years earlier than in unexposed subjects. These changes are often located nearby to operated motion segments. To the best of our knowledge, no controlled study exists with a follow-up as long as the current study. Previous investigations found a reduction in the height of operated disc in 80–100% of patients [11, 16, 19, 36] that was deemed severe in 12–62% of cases [11, 16, 36]. These findings are in keeping with our results and the high frequency of degeneration in the present study is likely to be attributable to the longer follow-up period. Indeed, other authors noted progression over time of disc space narrowing [33]. We hypothesize a role of discectomy in accelerating and worsening the natural long-term evolution of degeneration in the motion segment, even though this hypothesis could definitely be addressed in a study that compared patients with LDH, some of which did and did not undergo a discectomy. The high frequency of MRI and CT anomalies in the current study is also consistent with this hypothesis. Although the influence of age cannot be underestimated [10, 21, 29, 31], the combined effect of previous discectomy may help to explain the high frequency of considerable degenerative changes on MRI and CT scans.

We found that a recent history of pain was associated with presence of moderate to severe degenerative changes (e.g., severity score ≥ 2) on lumbar spine radiographs. No investigation reporting this relationship with a comparable long follow-up and validated outcome measures has been published up today. Despite a wide range of radiographic anomalies and clinical outcome measures were examined in previous studies, most frequently association has been found between the severity of loss of disc height, particularly at the L4–L5 level, and severe LBP, in both

dissectomized and non-operated patients [9, 12, 16, 27, 32, 34, 36]. Other studies failed to find any clinical radiographic correlation in patients with previous lumbar discectomy [11, 19, 26, 28, 33]. This discrepancy might be due to variability in outcome measures. Indeed, as in the current study, Peterson et al. [25] found a weak correlation of LBP severity ratings with severity of radiographic disc and facet joint involvement, whereas the ODI did not correlate with radiographic findings. We did not find significant relationships of MRI/CT degenerative changes with pain and disability. Although other authors [6, 29] pointed out the poor performance of MRI to predict LBP, this lack of association must be evaluated in the light of the small number of patients who had undergone advanced imaging in the current study.

We acknowledge that some features of the present study are non-ideal. A limitation is that patients enrolled represent only a small part of the entire cohort of operated patients and this could represent a potential bias in this study. Indeed, only patients who agreed to undergo radiographic examination participated in this study. Actually the relatively small sample size might be a greater problem for the effects not found than for those found and in the current study significant clinical radiographic relationships were detected despite the small study group. Moreover, our study group can be considered representative of the entire cohort, because patients had demographic and functional characteristics alike to patients not enrolled and similar to those recorded in other long-term studies [19, 20, 28, 36]. Another issue is represented by the choice of the control group that is less than optimal in this study. Indeed, the ideal control group should include people who do not have the exposure under investigation (discectomy) and who would be included in the study as cases if they had; therefore, in the current study ‘controls’ should have been selected among individuals with LDH treated conservatively in the same period as the participants of current study. This was impossible because at the time when our patients underwent surgery, it would have been deemed unethical to deny surgical therapy to patients with clinically proven LDH. On the other hand, selecting controls among subjects with common LBP and comparable follow-up duration as our patients would have been misleading because of the different baseline radiographic characteristics between cases (LDH) and controls (common LBP). However, this was a radiographic follow-up study and was mainly conceived to evaluate the long-term degenerative changes in subjects who had undergone lumbar discectomy many years earlier. These patients did not show changes on their preoperative imaging tests. They were carefully matched to asymptomatic subjects only to compare the different radiographic findings with or without previous discectomy. In other words, asymptomatic subjects in the present study should be regarded to as subjects

unexposed to discectomy rather than true control subjects. Due to the lack of an effective control group, we cannot exclude that the high frequency and severity of changes in our study group are caused by the combined effect of natural history of lumbar disc degeneration and surgery. Nevertheless, the high frequency of localization of changes in the operated intervertebral spaces and adjacent endplates allow us to claim the utmost pathogenic importance of discectomy. Conversely, the careful matching of patients with unexposed subjects represents a strength of this study because it enabled us to depurate the analysis of causal relationships for degeneration by the effect of several confounders, including the age of participants. Finally, the choice to evaluate lumbar degeneration by standard radiographs rather than by MRI examination could be criticized. However, one previous cadaver study [4] concluded that radiographic parameters are better able to distinguish different stages of lumbar spine degeneration than MRI anomalies. Moreover, the use of MRI scans to screen patients with back problems is more costly and associated with equivalent outcomes compared to standard radiographic examination [13].

Conclusions

Patients who had undergone lumbar discectomy a minimum of 21 years earlier present more frequently moderate to severe radiographic degenerative changes when compared to matched asymptomatic non-operated subjects. These changes particularly affect the operated segments. Patients also present high frequency of several MRI/CT anomalies. Despite people who are asymptomatic also show slight degenerative changes in their lumbar spine, the presence of significant degeneration is associated with a history of recent pain in patients but it does not influence significantly their functionality and quality of life. Although the level of satisfaction in these patients is high and the long time elapsed from surgery lessens its causal role on back problems in the elderly, the use of surgical techniques less aggressive than standard discectomy but equally effective to manage LDH may be assumed to help preventing long-term lumbar degeneration and its related clinical problems.

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