European Journal of Orthopaedic Surgery & Traumatology (2019) 29:313–320
https://doi.org/10.1007/s00590-018-2338-0

ORIGINAL ARTICLE • SPINE - IMAGING

Postoperative MRI findings 5 years after lumbar microdiscectomy

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Received: 27 April 2018 / Accepted: 3 November 2018 / Published online: 8 November 2018

Abstract

Background Lumbar microdiscectomy is a common procedure with satisfactory results; however, postoperative events like progressive adjacent level degeneration and perineural fibrosis can contribute to long-term pain. The purpose of the study was to evaluate MRI changes 5 years after lumbar microdiscectomy and assess their association with clinical parameters.

Materials and methods A prospective study enrolling 61 patients who underwent microdiscectomy. Changes between preoperative and postoperative MRI findings were recorded, and these findings were tested for associations with demographic, clinical and perioperative parameters. The measured imaging parameters were degeneration of the operated and adjacent discs and endplates, morphology of the disc herniation, facet joints arthritis and the presence of postoperative perineural fibrosis.

Results Statistically significant differences were found between preoperative and postoperative morphology of the operated disc, facet joints arthritis and degeneration of the operated and caudal adjacent disc. There were no differences between preoperative and postoperative disc degeneration of the superior adjacent disc and in degeneration of the operated and adjacent endplates. Postoperatively perineural fibrosis was common; however, thecal sac compression and nerve root impingement were reduced. Age at the time of surgery was the only parameter associated with postoperative changes.

Conclusion Five years after microdiscectomy, several postoperative MRI changes including operated disc's morphology, facet joints arthritis and degeneration of the operated and caudal adjacent disc were shown. Taking into consideration that participants were on average middle-aged, these changes could be attributed not only to the impact of the surgery but also to the natural history of lumbar spine degeneration.

Keywords Lumbar microdiscectomy · MRI changes · Degeneration · Perineural fibrosis

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Introduction

Lumbar disc herniation (LDH) has a lifetime incidence of 1–2% and is the most commonly operated-on spinal diagnosis. Lumbar microdiscectomy (LM) is a common procedure with satisfactory results; however, progressive degeneration, disc height loss, LDH on different levels, epidural fibrosis, arachnoiditis, foraminal stenosis and segmental instability can occur postoperatively, potentially contributing to long-term back and leg pain [1].

Postoperative disc degeneration has a complex multifactorial aetiology, and most evidence points to an age-related process influenced by mechanical and genetic factors [2]. Endplate changes are frequently noted in the endplates of vertebral bodies bordering severely narrowed discs, and osseous defects in endplates at the level of lumbar discectomy are common [3, 4]. Taking into consideration that surgery alters the anatomy and subsequently the forces applied to vertebrae, a postoperative aggravation of the degenerative process at the endplates of the operated level is anticipated [5].

Recurrent sciatica is of major concern for spine surgeons, and some of the several causes include postoperative epidural fibrosis or recurrent disc herniation. About 0.5–25% of patients develop recurrent disc herniation after a successful first discectomy [6]. A certain degree of perineural or epidural fibrosis is normal since scar tissue formation is a natural consequence after surgery. On the other hand, many authors have studied patients with recurrent sciatica and demonstrated that excessive epidural fibrosis may lead to recurrence of symptoms [7].

The aim of this study is to evaluate the long-term postoperative changes occurring at the operated area 5 years after microdiscectomy by comparing preoperative and postoperative MRI findings, taking into consideration demographic and clinical data. Several parameters were assessed including disc's morphology, thecal sac compression, nerve root impingement, facet joints' arthritis and the presence of perineural fibrosis on the operated level, disc degeneration and endplate changes of the operated and both adjacent levels.

Materials and methods

Patients and surgical technique

This was a prospective study conducted from January 2005 to June 2017 and approved by the University of Ioannina Medical School ethics committee. Each patient's written informed consent was obtained. One hundred and nine patients who underwent LM for a single-level LDH between January 2005 and June 2012 were initially enrolled. Inclusion criteria were chronic pain (defined as back and/or leg pain more than 6 weeks not resolving with conservative treatment) or deteriorating neurological signs. Exclusion criteria included discectomy in more than one level, lumbar spine trauma, history of lumbar spine operation, infection and primary or metastatic spinal tumour. LM was performed in all patients by the same experienced orthopaedic spine surgeon, using identical surgical protocol. A small incision (less than 2.5 cm) was made in the skin. Lumbar paraspinal muscles then were dilated gradually with increasingly larger tubular retractors to gain access to the spine with meticulous attention to minimize the disruption of epidural soft tissues. Only the ruptured portion of the disc was removed to decompress the spinal nerve root. Excessive disc removal and formal laminectomy was avoided.

Fifteen out of 109 patients were lost during follow-up and 3 refused to participate. Thirty patients were excluded because they didn't have both preoperative and postoperative MRIs available; consequently 61 patients with a mean age of 45.2 years (SD ± 12.5) at the time of surgery were considered eligible. The majority of them (35 patients, 57.4%) were females. Their median body mass index (BMI) was 26.2 (range 19–38). They were mainly urban residents (28 patients, 45.9%). Most patients ($n = 35$, 57.4%) received secondary education. Thirty-three patients (54.1%) were operated for L4–L5 LDH, 26 (42.6%) for L5-S1, 1 patient (1.6%) for L2–L3 and 1 patient (1.6%) for L3–L4 LDH. Twenty-seven patients (44.3%) were smokers, with a mean time of 25.2 (SD ± 15.7) pack years of tobacco exposure. Forty-four patients (72.1%) reported no alcohol use. The mean alcohol consumption of the remaining 17 patients was 11.9 alcoholic beverages per week. The median duration of preoperative symptoms was 120 days (range 4–1095). The majority of patients ($n = 46$, 75.4%) did not receive preoperative physical therapy. Seventeen patients (28.3%) reported having leg pain that lasted more than a year prior to operation. Twenty-three (37.7%) had a heavy physical work before and after the operation, 22 (36.1%) classified as having moderate work intensity and 11 (18.0%) had a sedentary work.

The mean operating time was 50 min and the average duration of postoperative hospitalization was 3.4 days (SD ± 1.99). No major perioperative complications were recorded. After the discharge from hospital, 2 patients (3.2%) developed superficial surgical wound infection, one of whom (1.6%) had a fever and wound drainage that required hospitalization for 7 days. Three patients (4.9%) were reoperated 1, 12 and 24 months after the initial surgery due to a true LDH recurrence (1 in L4–L5 and 2 in L5-S1 level), and 1 patient (1.6%) was reoperated 24 months after the initial surgery in order to remove fibrotic tissue pressing the S1 nerve root.

MRI findings

Imaging changes were assessed in lumbar spine MRIs performed preoperatively and at the end of the 5 year follow-up period by two independent experienced radiologists who were blinded to the clinical and surgical data. All MRIs were performed by the same scanner (1.5 Tesla, Symphony TM; Siemens, Erlangen, Germany) and under identical standardized protocol, which included: Diffusion (sagittal, b value = 0 and b value = 400), T2, STIR, T1 sagittal, T1 axial, T1 fat-saturated axial images, T1 axial fat-saturated post-contrast (gadolinium) and T1 sagittal fat-saturated post-gadolinium images. All sequences had 3-mm slice thickness. The evaluated imaging parameters included (1) morphology of the disc herniation, (2) presence of thecal sac compression or nerve root impingement, (3) facet joint arthritis, (4) presence of perineural fibrosis versus disc granulation, (5) degenerative disc changes and (6) degenerative endplate changes of the operated and adjacent levels. The disc morphology was classified according to the type of the herniation as normal/bulging, protruded and extruded/sequestered as described by Fardon [8]. Disc degeneration was graded on T2 spin-echo weighted images using Pfirrmann's grading system [9], and endplate degeneration was evaluated using the Modic classification system [10]. Facet joint arthritis was graded according to Weishaupt et al. [11] as normal (Grade 0), mild (Grade 1)/moderate (Grade 2) and severe (Grade 3).

Statistical analyses

Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS 20.0, Chicago, IL, USA). SPSS tests (t-test, sign test, Wilcoxon signed-rank test, McNemar–Bowker test, Bonferroni method) were used to compare each preoperative MRI finding with its corresponding postoperative. A logistic regression analysis was performed to test associations between various demographic and clinical parameters with MRI findings. p values < 0.05 were considered statistically significant; all p values were two-tailed.

Results

Disc morphology and neural compression

Preoperatively LDH had the form of protrusion in 32 patients (52.5%), extrusion or sequestration in 28 patients (45.9%) and broad-based disc protrusion in 1 patient (1.6%). Thecal sac compression was present in 31 patients preoperatively (50.8%). Nerve root was found compressed prior to operation in the majority of patients ($n = 38$, 62.3%). Neither perineural fibrosis ($n = 4$, 6.6%) nor disc granulation tissue ($n = 9$, 14.8%) were common findings in the post-gadolinium preoperative MRIs. Five years postoperatively the operated disc was classified as normal or mild bulging in the majority of patients (51 patients, 83.6%). Ten operated discs (16.4%) were protruding, but there was no extrusion or sequestration observed. Thecal sac was not compressed ($n = 21$, 34.4%) or compressed less than $^1/_3$ ($n = 31$, 50.8%) and the nerve root presented no impingement ($n = 21$, 34.4%) or just contact ($n = 28$, 45.9%). Perineural fibrosis was a very common postoperative MRI finding ($n = 50$, 82.0%).

Statistically significant differences between preoperative and postoperative MRIs exist in disc morphology on the level of discectomy. Postoperatively the operated disc caused an average less pressure on the adjacent tissues than preoperatively (negative differences = 55). Statistically significant difference was also found between pre- and postoperative compression on thecal sac ($p < 0.001$), which was less compressed postoperatively (negative ranks = 50). Statistically significant differences of nerve root impingement, perineural fibrosis and disc granulation tissue before and after discectomy were additionally found. Five years after discectomy, the nerve root on the operated level was less compressed but perineural fibrosis was more common ($p < 0.05$).

Disc changes

Degeneration of the operated disc preoperatively was classified as Pfirrmann Grade 4 in 30 patients (49.2%) and Grade 3 in 13 patients (21.3%) (Fig. 1). Preoperative degeneration of the cranial adjacent disc was classified mainly as Grade 3 ($n = 31$, 50.8%) or Grade 4 ($n = 26$, 42.6%). Degeneration of the caudal adjacent disc was assessed in 35 patients (57.4%) since the remaining 26 patients (42.6%) were operated for L5-S1 LDH and only the cephalad disc was graded; it was mainly Pfirrmann Grade 4 ($n = 15$, 42.9%), (Fig. 2). Post-discectomy degeneration of the operated disc was Pfirrmann Grade 4 in the majority of patients (34 patients, 55.7%). There were 15 patients (24.6%) in Grade 5 and 12 patients (19.7%) in Grade 3 (Fig. 1). The cranial adjacent disc degeneration was classified as Grade 3 in 30 patients (49.2%) and Grade 4 in 27 patients (44.3%). The distribution of Pfirrmann grades on the caudal adjacent disc was Grade 3 in 11 patients (31.4%), Grade 4 in 13 patients (37.1%) and 8 patients (22.9%) had Grade 5 (Fig. 2).

Statistically significant differences between preoperative and postoperative MRIs were found in disc degeneration of the operated level ($p < 0.001$) and in disc degeneration of the caudal adjacent level ($p = 0.04$). Postoperatively the operated and the caudal adjacent disc presented more often higher level of degeneration according to the Pfirrmann

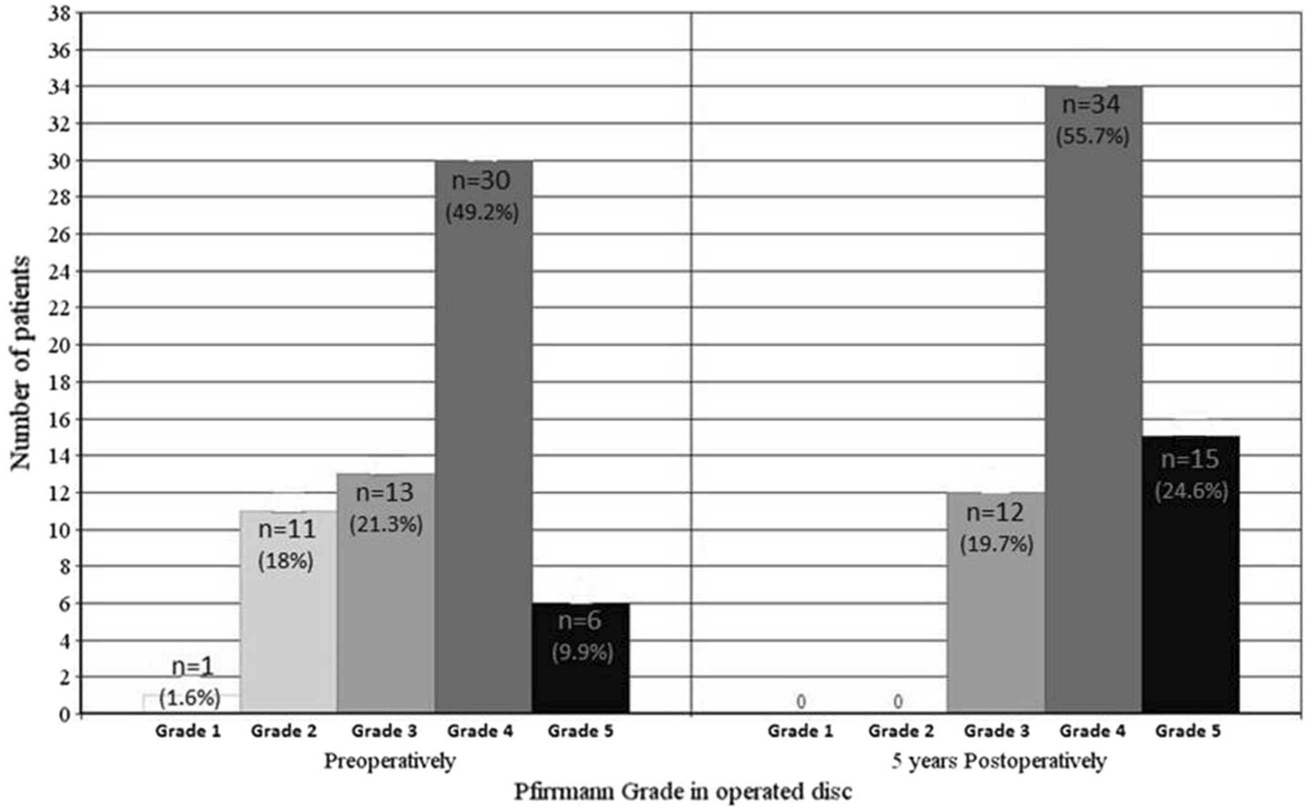

Fig. 1 Degeneration of the operated disc. Distribution of patients (their number is presented in the Y-axis) into Pfirrmann grades preoperatively (X-axis left) and postoperatively (X-axis right). The percentages of each grade are under its numerical value

classification than preoperatively (positive differences = 29 and 10, respectively). There was no statistically significant difference between preoperative and postoperative disc degeneration of the cranial adjacent disc ($p = 1.00$).

Endplates and facet joints changes

Before discectomy, almost half patients presented Modic changes (MC) on the operated level ($n = 29$, 47.5%), mainly of Type 2 ($n = 26$, 42.6%), but the majority had no preoperative MC on the cranial ($n = 37$, 60.7%), or caudal adjacent disc ($n = 24$, 68.6%). Preoperatively facet joints on the operated level were normal (Weishaupt Grade 0) in 23 patients (37.7%), presented mild (Grade 1) or moderate arthritis (Grade 2) in 37 patients (60.7%) and severe arthritis (Grade 3) in 1 patient (1.6%), (Fig. 3).

Postoperatively MC on the operated level were present in 43 patients (70.5%) at the end of the follow-up period. They were mainly Type 2 (31 patients, 50.8%) and Type 1 (9 patients, 14.8%). Only 3 patients (4.9%) had Modic Type 3 on the level of operation. Adjacent cranial level MC were recorded in 18 out of 61 patients (29.5%). They were Modic Type 2 in 12 patients (19.7%) and Type 1 in 6 patients (9.8%). Endplate changes of the inferior adjacent level were assessed in 35 patients (57.4%) since the remaining 26 patients (42.6%) were operated for L5-S1 LDH. Twenty-two patients out of 35 (62.9%) had no MC, 9 patients (25.7%) had MC Type 2 and three patients (8.6%) had Type 1. Facet joint arthritis (Weishaupt Grades 1–3) was present in the postoperative MRI of 48 patients (78.7%) and was considered mild (Grade 1) or moderate (Grade 2) in 41 patients (67.2%) and severe (Grade 3) in 7 out of 48 patients (11.5%), (Fig. 3).

Statistically significant differences between preoperative and postoperative MRIs were found in facet joints arthritis ($p < 0.001$). Aggravation was observed in facet arthritis (positive differences = 50). As far as the MC are concerned no differences existed between preoperative and postoperative MRIs, neither on the operated disc ($p = 0{,}157$) nor on the adjacent discs ($p = 0{,}343$ on the cranial adjacent disc, $p = 0{,}135$ on caudal adjacent disc).

Demographics' and clinical parameters' associations with postoperative MRI findings

A logistic regression analysis was performed to evaluate possible associations between demographic and clinical data with postoperative MRI findings. The parameters

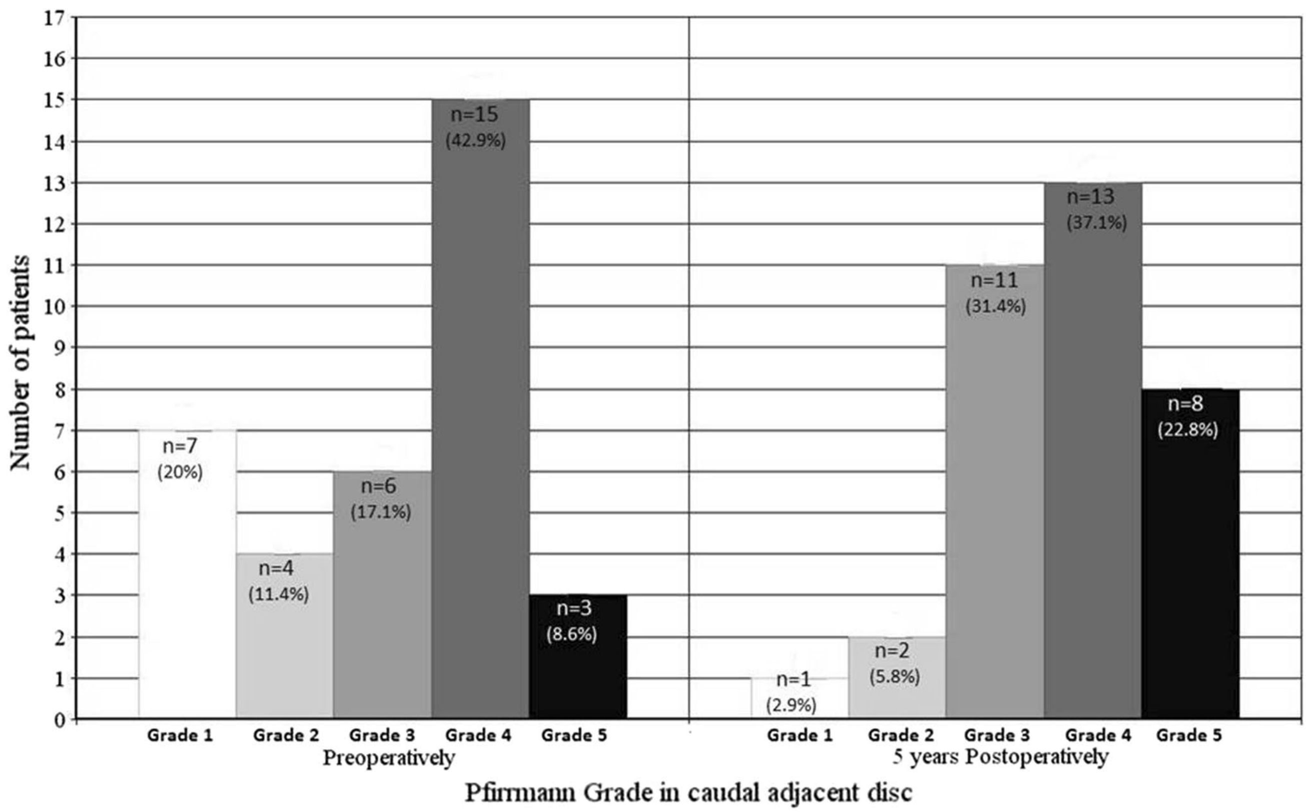

Fig. 2 Degeneration of the caudal adjacent disc (in 35 patients, since the remaining 26 patients were operated for L5-S1 LDH and only the cranial adjacent disc was graded). Distribution of patients (their number is presented in the Y-axis) into Pfirrmann grades preoperatively (X-axis left) and postoperatively (X-axis right). The percentages of each grade are under its numerical value

tested included sex, age at surgery, BMI, LDH level, smoking, alcohol use, type of occupation, duration of preoperative symptoms, postoperative physiotherapy and swimming rehabilitation program. No association was found between the majority of these parameters and MRI findings such as thecal sac compression, nerve root impingement, perineural fibrosis, formation of disc granulation tissue, disc degeneration, endplate changes and facet osteoarthritis ($p > 0.05$). The only statistically significant association found was between age at the time of surgery and postoperative disc degeneration of the cranial adjacent disc [$p = 0.04$, odds ratio Exp(B) = 1.079, 95% confidence intervals for Exp(B) = 1.003–1.161)], postoperative endplate changes of the cranial level [($p = 0.007$), odds ratio Exp(B) = 1.206, 95% confidence intervals for Exp(B) = 1.054–1.380)] and postoperative facet joints arthritis of the operated level [($p = 0.04$), odds ratio Exp(B) = 1.263, 95% confidence intervals for Exp(B) = 1.005–1.586)]. Such associations were not found preoperatively.

Reoperation due to real disc recurrence or due to pressure from fibrotic tissue was not statistically related to any clinical, demographic or MRI variable tested in this study (p from > 0.001 to 0.041).

Discussion

Twenty-nine patients (47.5%) of our study had preoperative degenerative endplate changes in the level of discectomy, mainly of Modic Type 2 ($n = 26$, 42.6%), but the majority did not have endplate changes in the cranial ($n = 37$, 60.7%) or caudal ($n = 24$, 68.6%) adjacent disc. Five years after microdiscectomy, there were no changes in any lumbar level compared to the preoperative images, but there was an aggravation of disc degeneration in the operated level, minimal changes in the caudal adjacent level and almost no changes in the cranial adjacent disc.

Regarding disc degeneration, Briseño et al. did not find any correlation between preoperative, 3-month and 1-year postoperative scores [12]; Dalgic reported that discectomy accelerates the degenerative process associated with ageing and that the responses of the operated disc and vertebral body unit to axial compression are transferred to adjacent segments [13]. Huang et al. in a systematic review and meta-analysis showed that disc height, BMI and MC were significantly correlated with a higher incidence of recurrent LDH [14]. On the other hand, Swartz et al. [15], similarly to our study, found that age, sex, smoking, level of herniation and

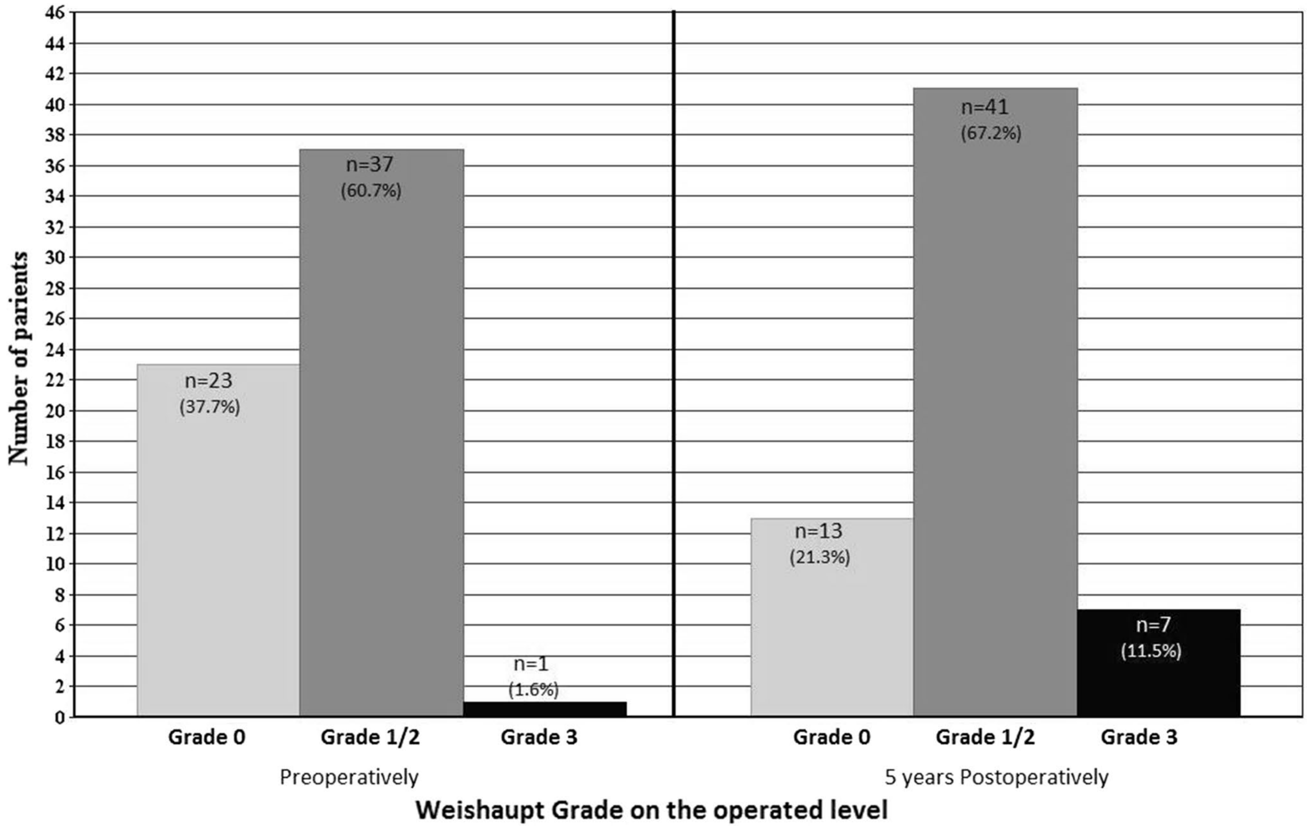

Fig. 3 Facet joints' arthritis on the operated level. Distribution of patients (their number is presented in the Y-axis) into Weishaupt grades preoperatively (X-axis left) and postoperatively (X-axis right). The percentages of each grade are under its numerical value. Weishaupt Grade 0 = normal, Grade 1/2 = mild/moderate, Grade 3 = severe arthritis

symptom duration were not associated with recurrence after discectomy.

Although much effort has been made, there is no absolutely effective technique that we currently have to reduce perineural fibrosis formation after lumbar disc surgery [16]. The fibrosis-entrapped nerve root is more susceptible to compression due to the tethering effect of the scar tissue around. We recorded a significant increase in perineural fibrosis formation 5 years after discectomy ($n = 50$, 82.0%) compared to preoperative perineural fibrosis ($n = 4$, 6.6%). An interesting point of our study was that although postoperative perineural fibrosis was evident in many cases, nerve root and thecal sac compression were substantially decreased postoperatively. Furthermore, we found no association between perineural fibrosis and demographic and clinical data.

There are some limitations of this study that must be addressed. There is no assessment of low back pain or outcome scores to correlate with the radiological findings. Also there was no control group, so there is no comparison between the degenerative changes noted after discectomy with changes after conservative treatment. However, several studies investigated radiological changes in the lumbar spine of patients with LDH conservatively treated at variable follow-up intervals [17, 18]. In addition, several degenerative changes in the lumbar spine have been reported as incidental imaging findings of asymptomatic subjects [2, 19–22]. These studies suggest that radiographic degeneration is common, and its incidence increases with age, especially in the lowest levels of lumbar spine [18, 23, 24]. In some studies, the prevalence of lumbar intervertebral disc degeneration increased progressively to over 90% by 50–55 years of age [18].

In our study, the comparison between pre- and postoperative MRI findings 5 years after LM recorded only a few degenerative postoperative changes which were associated with the age of patients at the time of surgery. The aetiology of spinal degeneration is complex and multifactorial, in which ageing plays a key role, even if no other risk factors exist. The association of ageing and spine degeneration was reported in many studies that do not include a surgical procedure in the lumbar spine. Powell et al. [25] reported that 30% of 20–29-year-old subjects and 90% of 70–79-year-old subjects in their study had lumbar intervertebral disc degeneration. Zheng and Chen [26] showed that lumbar intervertebral disc degeneration increases with age. Boos et al. [27]

reported a steady increase in intervertebral disc degeneration scores with age in a histological study of deceased subjects (age range 0–88 years). Therefore, if we take into consideration that in our study the mean age of patients at the end of the follow-up period was 50 years of age, these degenerative changes could also be attributed to the natural history of lumbar spine degeneration and not only to the impact of surgery. However, it is very difficult to determine the exact amount of risk associated with each cause in such a multifactorial phenomenon as the degeneration of lumbar spine.

Conclusion

Five years after lumbar microdiscectomy, degenerative changes were presented in MRI, which did not exist preoperatively and they were statistically associated with patients' older age at the time of surgery (and therefore older at the end of the 5-year follow-up period). Participants were on average middle-aged at the end of the follow-up and we would expect them to present some degree of degeneration, even if they were not operated. Consequently it is not easy to absolutely define whether these changes are attributed to the natural history of lumbar spine degeneration or to the impact of the surgery and to what extent.

Compliance with ethical standards

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

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