ORIGINAL ARTICLE

Lumbar Microdiscectomy: A Clinicoradiological Analysis of Outcome

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ABSTRACT: ***Background:*** The long-term outcome after lumbar microdiscectomy (LMD) may be affected by low back pain (LBP) and segmental instability, the determinants of which remain unclear. We sought to analyze the interaction between clinical, functional, and radiological variables and their impact on patient outcome. ***Methods:*** All patients who underwent LMD in 2004-2005 were invited to participate in this retrospective cohort study. Patients were re-evaluated clinically and radiologically after a three to five year follow-up. ***Results:*** Forty-one of 97 eligible patients were enrolled. Twelve patients (29.3%) reported moderate-to-severe sciatica, 12 (29.3%) had moderate LBP, and 13 (31.7%) exhibited clinical evidence of segmental instability. Thirty-eight patients (92.7%) had minimal disability and 3 (7.3%) had moderate disability. Twenty-three patients (56.1%) were fully satisfied, while 18 (43.9%) had only partial satisfaction, having expected a better outcome. Thirty-three patients (80.5%) returned to full-time work. Median disc space collapse (DSC) was 20% (range 5-66%) and L4-L5 was particularly affected. Prevalence of Modic changes increased from 46.3% to 78% with type 2 predominance. Multivariate logistic regression analysis identified the following negative prognostic factors: female sex, young age, lack of regular exercise, and chronic preoperative LBP. There was no correlation between the course of Modic changes, DSC, and patient outcome. ***Conclusion:*** Although many patients may be symptomatic following LMD, significant disability and dissatisfaction are uncommon. Female sex, young age, lack of exercise, and chronic preoperative LBP may predict a worse outcome. Disc collapse is a universal finding, particularly at L4-L5. Neither DSC nor Modic changes seem to affect patient outcome.

RÉSUMÉ: Analyse clinico-radiologique des résultats de la microdiscectomie lombaire. ***Contexte :*** Le résultat à long terme de la microdiscectomie lombaire (MDL) peut être influencé par la douleur lombaire (DL) et l'instabilité segmentaire dont les facteurs déterminants sont mal connus. Le but de notre étude était d'analyser l'interaction entre des variables cliniques, fonctionnelles et radiologiques ainsi que leur impact sur le résultat chez le patient. ***Méthode :*** Tous les patients qui ont subi une MDL en 2004-2005 ont été invités à participer à cette étude rétrospective de cohorte. Tous les patients ont subi une nouvelle évaluation clinique et radiologique après un suivi variant de 3 à 5 ans. ***Résultats :*** Quarante et un des 97 patients éligibles ont participé à l'étude. Douze patients (29,3%) présentaient une sciatalgie de modérée à sévère, 12 (29,3%) présentaient une DL modérée et 13 (31,7%) présentaient des signes cliniques d'instabilité segmentaire. Trente-huit patients (92,7%) avaient une invalidité minime et 3 (7,3%) avaient une invalidité modérée. Trente-trois patients (56,1%) étaient entièrement satisfaits du résultat et 18 (43,9%) s'étaient attendus à de meilleurs résultats et étaient donc partiellement satisfaits. Trente-trois patients (80,5%) étaient retournés au travail à temps complet. L'affaissement médian de l'espace discal (AED) était de 20% (écart de 5% à 66%) et l'espace L4-L5 était particulièrement touché. La prévalence de changements Modic a augmenté de 46,3% à 78%, avec prédominance de changements de type 2. L'analyse de régression logistique multivariée a identifié les facteurs indiquant un pronostic défavorable : le sexe féminin, le jeune âge, l'absence d'exercice régulier et la présence de DL chronique avant la chirurgie. Il n'existait pas de corrélation entre l'évolution des changements Modic, l'AED et le résultat chez le patient. ***Conclusion :*** Bien que plusieurs patients éprouvent des symptômes après la MDL, ils présentent rarement une invalidité significative ou de l'insatisfaction. Certains facteurs, tels le sexe féminin, le jeune âge, le manque d'exercice et la DL chronique préopératoire, peuvent prédire un moins bon résultat. L'affaissement de l'espace discal est une constatation universelle, particulièrement au niveau L4-L5. Ni l'AED, ni les changements Modic ne semblent influencer le résultat chez le patient.

Can. J. Neurol. Sci. 2011; 38: 439-445

While short-term results of lumbar microdiscectomy (LMD) are favorable in over 85% of cases, long-term outcome is often less rewarding and tends to be similar to that of nonoperative management of lumbar disc herniation (LDH), with only 55-70% favorable results[1-6]. Low back pain (LBP) is the usual cause for the drop in patient satisfaction and has been linked to the development of post-operative segmental instability (SI)[1,6-13].

However, whether instability is a direct consequence of surgery or whether it is part of the natural history of lumbar degenerative disc disease (DDD) is still a matter of debate[6,14,15]. Some authors have suggested that post-operative disc space collapse (DSC) of more than 25-30% after aggressive discectomy may be associated with a higher rate of LBP and worse clinical outcome[9-13,16]. Moreover, Modic changes, particularly those of type 1, have often been viewed as markers

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Received September 21, 2010. Final Revisions Submitted November 18, 2010.
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Table 1: Clinical criteria for segmental instability[7]

Criterion	Definition
Apprehension (symptom)	Anxiety resulting from a sensation of collapse of the lower back because of sudden onset of lumbar pain during movement
Instability catch (sign)	Patient is asked to bend the body forward as far as possible and then return to the erect position, test is abnormal if the return from the bent position fails because of a sudden attack of LBP
Painful catch (sign)	Patient is asked to lift up a straightened leg and lower it then go slowly back on the examination couch, test is abnormal if the leg suddenly drops because of sharp LBP

Segmental instability is defined by the presence of at least one of the three clinical criteria

of underlying active degeneration and instability[17,18], but it is still unclear whether their presence affects patient outcome after LMD.

The purpose of this study was to analyze the interaction between clinical, functional, and radiological variables and their impact on patient outcome following LMD.

Patients and Methods

Study Design

All patients who underwent single-level unilateral LMD by the senior author (NO) in 2004-2005 were contacted in 2007-2008 and invited to participate in this retrospective cohort study. Exclusion criteria were: previous back surgery (non virgin lumbar spine), recurrent LDH, sequestrectomy without discectomy, far-lateral LDH requiring a transmuscular approach, aggressive surgery (laminectomy or facetectomy), concomitant lumbar fusion, and unavailable preoperative magnetic resonance imaging (MRI). The study protocol was approved by the university's Ethics Committee and written informed consent was obtained from patients prior to their enrollment.

Medical records and preoperative MRIs were reviewed and baseline demographic, clinical, radiological, and operative data were collected. At the time of follow-up, patients underwent detailed clinical evaluation and repeat lumbar spine MRI. Outcome measures were:

- presence and intensity of sciatica according to a visual analog scale (VAS),
- presence and intensity of axial LBP (VAS),
- presence of SI according to the clinical criteria of Kotilainen and Valtonen[7] (Table 1),
- level of functional disability according to the Oswestry Disability Index (ODI) version 2.0[19],
- level of patient satisfaction according to the Patient Satisfaction Index (PSI)[11-13,20] (Table 2),
- work status[21] (Table 3),
- degree of post-operative DSC according to the technique of Mochida et al[16] (Figure 1), and
- course of Modic changes at the operated level.

Given the lack of consensus on a radiological definition of instability[18,22], dynamic flexion-extension radiographs were not performed. Instead, we relied on clinical criteria of SI which may better correlate with patient outcome after LMD[7,8,10].

Surgical Technique

All discectomies were performed by the same surgeon (NO) using a standard microsurgical interlaminar fenestration

Table 2: Patient satisfaction index[11-13,20]

Grade	Definition
1	"Surgery met my expectations"
2	"I did not improve as much as I had hoped but I would undergo the same operation for the same results"
3	"Surgery helped but I would not undergo the same operation for the same results"
4	"I am the same or worse as compared to before surgery"

PSI 1 or 2: satisfactory outcome, PSI 3 or 4: unsatisfactory outcome

https://doi.org/10.1017/S0317167100011847 Published online by Cambridge University Press

technique[23]. Patients are usually placed in the lateral position and undergo spinal anesthesia. A small 3-4 cm midline skin incision is performed and subcutaneous tissues are dissected. The thoracolumbar fascia and supraspinous ligament are divided by monopolar cautery. Paraspinous muscles are subperiosteally dissected using monopolar cautery and a Cobb elevator, until the ligamentum flavum and hemilaminae above and below the interspace are well exposed. A Williams retractor is placed and the operating microscope is introduced. The ligamentum flavum is incised with a scalpel blade and resected in a piecemeal fashion using a microcurette and a Kerrison rongeur, until the spinal canal is entered and epidural fat is identified. Occasionally, a small laminotomy or foraminotomy are performed to facilitate access to the spinal canal. The epidural fat is dissected using a dental microdissector until the dural sac is exposed and the nerve root identified in its lateral recess. The latter is retracted medially to expose the underlying disc herniation. The posterior longitudinal ligament is incised with a scalpel blade and the herniated disc fragment removed using a fine pituitary rongeur and a nerve hook. At this point, the disc space is penetrated and the degenerated nucleus pulposus removed in a piecemeal fashion using a pituitary forceps and a microcurette. Discectomy is pursued until all loose and easily mobilizable disc fragments are resected. Aggressive resections of the annulus fibrosus are never attempted. Similarly, endplate curettage is never performed and endplate injury is avoided at all times. At the end of the procedure, the surgical field is irrigated profusely and meticulous hemostasis is obtained, followed by epidural infiltration of methylprednisolone acetate (Depomedrol™). Finally, the wound is closed in layers in a standard fashion. The typical operative time is 45-60 minutes. Patients are encouraged to ambulate on the day of surgery and are typically discharged on the first post-operative day. They are instructed to avoid prolonged sitting for at least four weeks following surgery and are referred for outpatient physical therapy.

Table 3: Work status [21]

Grade	Definition
1	Full-time return to original work
2	Part-time return to original work
3	Different light-duty work
4	Disability

$$\% \, DSC = \frac{\frac{d1}{b1} - \frac{d2}{b2}}{\frac{d1}{b1}} \times 100$$

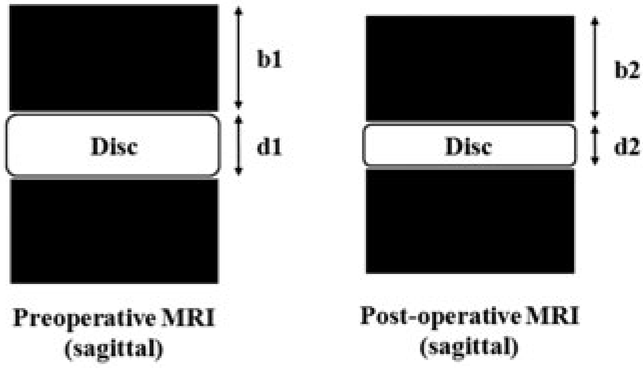

Figure 1: *Technique of measurement of disc space collapse.*[16]

Statistical Analysis

Outcome was analyzed at three different levels:
- clinical: sciatica, LBP, and SI;
- functional: ODI, PSI, and work status; and
- radiological: DSC and course of Modic changes.

The following preoperative variables were tested as potential prognostic factors for each of the outcome measures: sex, age, pattern of exercise, duration of preoperative sciatica, presence and duration of preoperative LBP, disc level, and presence and type of preoperative Modic changes. Univariate analysis was performed using Fisher's exact test for categorical variables and Wilcoxon rank sum test for numerical variables. Statistically significant variables were introduced in a multivariate analysis model using logistic regression with backward elimination.

The correlation between DSC and course of Modic changes and the impact of these radiological findings on the clinical and functional outcomes were analyzed using Fisher's exact test for categorical variables and Wilcoxon rank sum test and Pearson correlation test for numerical variables.

All statistical tests were performed using SPSS Statistics version 17.0 (SPSS Inc., Chicago, IL, USA). Statistical significance was set at $p < 0.05$.

Results

Study Population

During the study period, 97 patients met the inclusion and exclusion criteria. One patient had died from an unrelated cause and 19 patients were living abroad and could not be contacted. From the remaining 77 patients, 3 refused to undergo repeat MRI because of claustrophobia and 20 (20.6%) refused to participate in the study. Of the 54 consenting patients, 13 had to be excluded because their preoperative MRI was unobtainable. The

https://doi.org/10.1017/S0317167100011847 Published online by Cambridge University Press

remaining 41 patients constitute our study population. Power analysis showed that this sample had only limited power in detecting subtle effects on outcome when logistic regression was used. Assuming a 5% type 1 error, this sample had 80% power to detect an increase in the probability of poor outcome from 30% to:

- 75.7% (odds ratio 7.27) in response to the presence of a binary variable in 30% of patients and
- 52.7% (odds ratio 2.6) in response to an increase of one standard deviation above the mean for a continuous normal variable.

There were 27 males and 14 females with a mean age of 54 years (range 24-78 years). Recalcitrant pain or failure of medical therapy was the indication for surgery in the vast majority of cases (38 patients, 92.7%), while three patients (7.3%) had progressive motor deficit. There were no instances of cauda equina syndrome in this cohort. Forty patients (97.6%) presented with sciatica and one (2.4%) with LBP. The latter was present overall in 31 patients (75.6%). The median duration of sciatica was four weeks (range 1-52 weeks) and that of LBP was eight weeks (range 1-52 weeks). Six patients (14.6%) suffered from chronic LBP more than (>) six months before surgery. Twenty-two patients (52.7%) had motor deficit which was mild or moderate (3-4/5) in all but one patient, the latter having complete paralysis in the territory of the affected nerve root. In addition, 11 patients (26.8%) had sensory deficit and 20 patients (48.8%) had diminished deep tendon reflexes in the affected territory. L4-L5 and L5-S1 were the affected levels in the vast majority of cases (36 patients, 87.8%) (Figure 2). Modic changes adjacent to the LDH were identified preoperatively in 19 patients (46.3%), all at L4-L5 and L5-S1. Type 2 changes were most prevalent and were seen in 14 patients (34.1%), while type 1 changes were found in five patients (12.2%). There were two surgical complications: one unintentional durotomy and one transient post-operative urinary retention. There was no permanent morbidity or mortality in this series. Median follow-up was 41 months (range 32-59 months).

Clinical Outcome

At the time of follow-up, 12 patients (29.3%) reported persistent moderate or severe (VAS > 3) sciatica (Figure 3). One patient (2.4%) suffered from severe sciatica (VAS > 6), while 11 (26.8%) had only moderate sciatica (VAS 4-6). In addition, 12 patients (29.3%) suffered from moderate LBP, but none reported severe LBP (Figure 3). Finally, 13 patients (31.7%) had clinical evidence of SI. Of the three criteria, apprehension was by far the most common and affected 11 patients (26.8%), while instability catch and painful catch were reported only by three (7.3%) and one (2.4%) patients, respectively. At the time of follow-up, 25 patients (61%) had either moderate or severe sciatica, moderate LBP, or SI.

Forty patients (97.6%) had normal motor strength (5/5) in their lower extremities, while one (2.4%) had a slight residual motor deficit ($4^+/5$) in the affected nerve root territory. Similarly, 40 patients (97.6%) had a normal sensory exam, while one (2.4%) had mild residual hypoesthesia in the affected dermatome. Finally, 39 patients (95.1%) had normal deep tendon reflexes, while two (4.9%) had persistent areflexia in the affected territory.

Functional Outcome

At the time of follow-up, 38 patients (92.7%) had only minimal disability (ODI less than (<) 20%), only 3 (7.3%) had moderate disability (ODI 20-40%), and none had severe disability. Median ODI score was 4.4% (range 0-28.9%).

All patients were satisfied to some extent and would have accepted to undergo surgery again for the same results. While 23 patients (56.1%) were fully satisfied (PSI 1), 18 (43.9%) had hoped for a somewhat better improvement (PSI 2). There were no PSI grades 3 or 4 in this series.

Finally, 33 patients (80.5%) had returned full-time to their original work, while a change in working conditions was necessary in eight patients (19.5%) (Figure 4).

Radiological Outcome

At the time of follow-up, all operated discs exhibited at least some degree of height loss and the median DSC was 20% (range

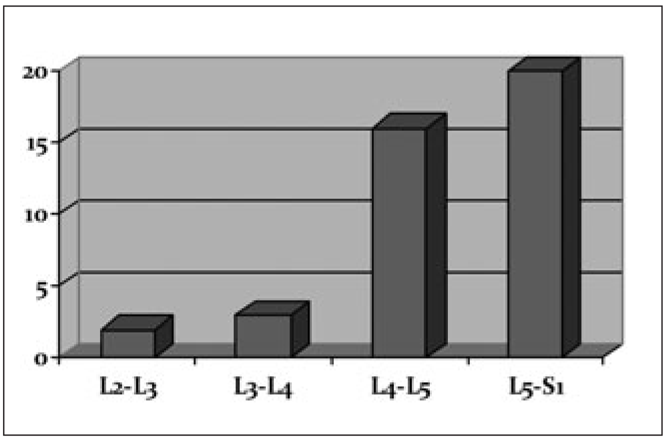

Figure 2: *Distribution of LDH according to disc level (N = 41).*

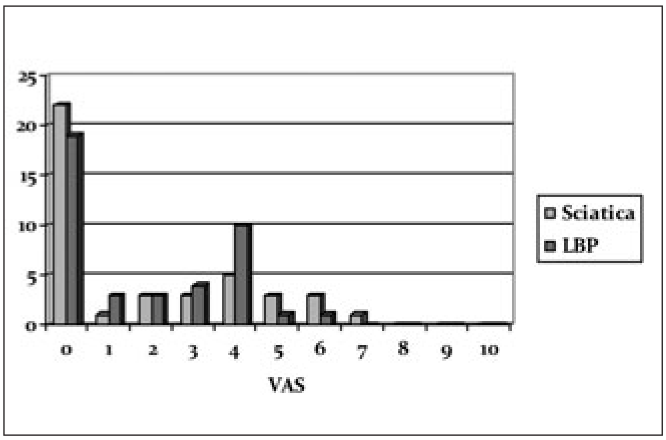

Figure 3: *Sciatica and LBP at the time of follow-up (N = 41).*

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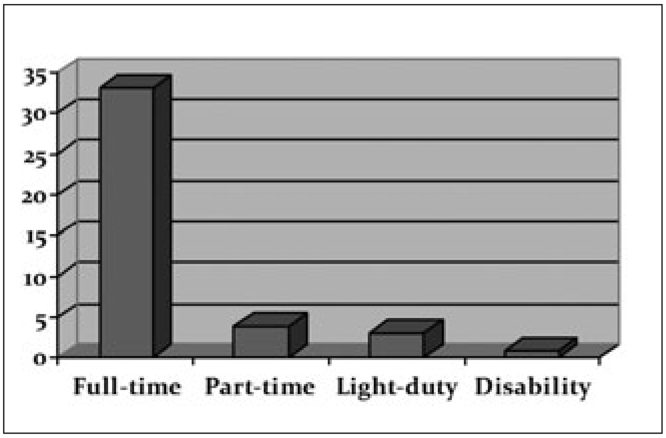

Figure 4: *Work status of patients (N = 41).*

5-66%). Severe DSC (> 30%) was present in 11 patients (26.8%).

During follow-up, the prevalence of Modic changes at the operated level increased from 46.3% (19 patients) to 78% (32 patients) as most patients developed *de novo* lesions, particularly type 2. In addition, most Modic 1 changes converted to type 2 and most nonconverted Modic 1 and 2 lesions progressed in size. At follow-up, 26 patients (63.4%) had Modic 2 changes at the operated level.

Prognostic Factors

On univariate analysis, the following statistically significant associations were observed:

- female sex and higher rate of moderate or severe disability (21.4% vs. 0% in men, p=0.034),
- female sex and higher rate of job change (42.9% vs. 7.4% in men, p=0.012),
- younger age at surgery in patients with segmental instability (mean 47 years vs. 57 years, p=0.047),
- regular exercise and lower rate of sciatica (16.7% vs. 58.6%, p=0.019),
- regular exercise and higher rate of full satisfaction (83.3% vs. 44.8%, p=0.038),
- preoperative LBP > 6 months and higher rate of moderate or severe disability (33.3% vs. 2.9%, p=0.05),
- disc level L4-L5 and higher rate of severe DSC (50% vs. 12%, p=0.012), and
- preoperative Modic 2 changes and higher rate of moderate or severe disability (21.4% vs. 0%, p=0.034).

Multivariate logistic regression analysis identified the following independent negative prognosticators: female sex, young age at surgery, lack of regular exercise, and preoperative LBP > 6 months. In addition, L4-L5 disc level was predictive of severe DSC (Table 4).

Clinical-Radiological Correlations

Although not statistically significant, there was a trend for association between conversion to Modic 2 and lower rate of moderate LBP at follow-up (8.3% vs. 37.9%, p=0.073). In contrast, the course of Modic changes did not correlate with the presence of sciatica or SI, disability score, patient satisfaction, or work status. Similarly, there was no correlation between DSC and any of the clinical and functional outcome variables. However, there was a positive correlation between ODI score and each of the clinical variables: post-operative sciatica (p=0.006), moderate post-operative LBP (p=0.004), and SI (p=0.002). Finally, there was no correlation between the course of Modic changes and DSC.

Discussion

Presence of Symptoms

In this series, three to five years after LMD, 29.3% of patients had significant sciatica, 29.3% had significant LBP, and 31.7% had clinical evidence of SI. These results are in agreement with those of larger series[4,6,7,9,14,24,25]. In a recent systematic review of the literature, McGirt et al[24] found that reported rates of either sciatica or LBP after a minimum two-year follow-up following lumbar discectomy varied between 19 and 37%. In the series of

Table 4: Multivariate analysis of prognostic factors

Outcome Variable	Predictive Variable	OR	95%CI	p
Sciatica	Regular exercise	0.14	0.03-0.76	0.023
LBP	None	N/A	N/A	N/A
SI	Age	0.95	0.90-1.00	0.047
Disability (ODI > 20)	Preop LBP > 6 months	17.00	1.24-232.22	0.034
Full satisfaction (PSI 1)	Regular Exercise	6.15	1.14-33.20	0.035
Job change	Female sex	9.38	1.57-56.01	0.014
Severe DSC (> 30%)	Disc level L4-L5	7.33	1.55-34.70	0.012
Modic conversion/progression	None	N/A	N/A	N/A

OR: odds ratio, 95%CI: 95% confidence interval, LBP: low back pain, SI: segmental instability, ODI: Oswestry Disability Index, PSI: Patient Satisfaction Index, DSC: disc space collapse, Preop: preoperative, N/A: not applicable

Kotilainen and Valtonen[7], symptoms and signs of SI were present in 22% of patients after a mean follow-up of three years.

It may be argued that there was no radiological assessment of segmental instability, i.e. dynamic flexion-extension radiographs, in this study. Although classically a radiological concept, segmental instability of the lumbar spine still lacks a consensual radiographic definition[18,22]. Moreover, there is very limited correlation between radiological intervertebral motion and patient symptoms[22]. In contrast, a strong association has been documented between clinical instability after LMD and unsatisfactory long-term patient outcome, including occurrence of LBP, disability in daily activities, and loss of working capacity[7,8].

Disability and Satisfaction

Contrasting with the high prevalence of symptoms (61%), functional outcome was remarkably favorable in this patient population: 92.7% had only minimal disability (ODI < 20%), 100% were at least partially satisfied, and 80.5% returned to full-time work. These findings are also comparable to the literature, particularly in regards to the high rates of satisfaction (93-95%)[14,15,26] and full-time return to work[7,27] that are commonly reported after lumbar discectomy. In the series of Loupasis et al[14], 66% of patients had mild disability and the mean ODI score was 18.9%. The lower mean ODI score (4.4%) in the present series may possibly be related to our shorter follow-up (3-5 years vs. 7-20 years). Alternatively, the significant number of patients lost to follow-up in our retrospective study may have introduced a selection bias leading to underestimation of the rate of unfavorable functional outcome. However, the direction of such a bias, in our opinion, would be completely unpredictable. In fact, symptomatic patients may have been well over-represented as these would have been particularly motivated to undergo clinical evaluation and repeat MRI. This possibility is further supported by the relatively high rate of symptomatic patients in this series.

Clinical Prognosticators

Young age at the time of surgery appears to predict a higher risk of post-operative SI. Our finding is supported by the works of Yorimitsu et al[9] and Schaller[10]who observed that the majority of patients suffering from severe LBP and SI were young. This might be explained by a more active degenerative process in younger patients[9], a more advanced stage of DDD leading to a lower risk of post-operative instability in older patients[10], and more frequent involvement of younger patients in intense physical activity[9].

Similarly to others[14,28], we have also found that female sex can predict a worse functional outcome and a higher rate of change in working conditions. It is possible that psychosocial, hormonal, and genetic factors may all contribute to this finding.

In contrast, unlike what has been observed by other authors[29-33], the duration of preoperative sciatica had no impact on patient outcome. However, it must be noted that the vast majority (90%) of patients in this series were operated on within three months of the onset of their symptoms. Subsequently, our results may have been affected by our somewhat aggressive approach to symptomatic LDH and thus may not be necessarily generalizable to patients operated after three months by more conservative spine surgeons.

Finally, we were able to identify two previously unrecognized prognostic factors:

- Of patients with preoperative LBP lasting six months or more, one third had moderate or severe disability at the time of follow-up. In contrast, only less than 3% of patients without LBP or with short-term preoperative LBP had significant disability. We propose that chronic preoperative LBP is a marker for underlying SI which could be easily worsened by the acute destabilizing effects of disectomy. Thus, the importance of careful patient selection for LMD based on clinical criteria cannot be overemphasized.
- Conversely, regular exercise was associated with both a lower rate of post-operative sciatica and a higher degree of patient satisfaction. In addition to its beneficial effect on the musculature of the back and abdomen which may protect against DDD and LBP, regular exercise may also have a positive psychological impact on patients, thus accounting for the higher degree of satisfaction in these patients. Whenever possible, we encourage patients to engage in regular exercise after undergoing LMD.

Radiological Findings

Radiologically, all patients exhibited at least some degree of DSC, a finding that has been similarly noted by others[14,26]. Whether the degree of DSC has an impact on patient outcome is still a matter of debate[9,13,14,16,26]. Although we could not document such a relationship, we found an association between disc level and degree of DSC with L4-L5 discs being much more prone to collapse than L5-S1 discs. While the exact reason for this remains unclear, biomechanical factors are likely to account for this phenomenon.

Although their presence has often been associated with LBP and SI[13,17,18], neither the presence nor the type of preoperative Modic changes had any impact on the clinical and functional outcomes in this series. Our finding is similar to that of Chin et al[34] who documented similarly satisfactory results following LMD in both patients with and without preoperative Modic changes. It would have been interesting to separately analyze the subgroup of patients with type 1 Modic changes as these are often considered to be markers of biomechanical instability[17,18]. Unfortunately however, such a subgroup analysis was not possible given the small number of patients with Modic 1 changes in this series.

Conclusion

Although more than 60% of patients may suffer from persistent sciatica, chronic LBP, or SI following LMD, their functional outcome remains remarkably favorable with high rates of satisfaction and return to full-time work. While young age at the time of surgery, female sex, and a preoperative LBP of > 6-month duration are associated with worse clinical and functional outcomes, regular exercise seems to protect against post-operative sciatica and to promote patient satisfaction. Disc space collapse is a universal finding following LMD that predominantly affects the L4-L5 disc. Neither the degree of DSC nor the presence and type of preoperative Modic changes seem to affect clinical and functional outcomes.

Acknowledgements

The authors thank Ms. Fahime Chehwane for her invaluable assistance in the implementation of this project.

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