JOURNAL OF NEUROSURGICAL SCIENCES

VOLUME 58 • No. 2 • JUNE 2014

PUBBLICAZIONE PERIODICA TRIMESTRALE - POSTE ITALIANE SPA - SPED. IN A.P. D.L. 353/2003 (CONV. IN L. 27/02/2004 N° 46) ART. 1, COMMA 1, DCB/CN - ISSN 0390-5616 TAXE PERÇUE

PUBLISHED BY MINERVA MEDICA

Two-year follow-up after microsurgical discectomy and dynamic percutaneous stabilization in degenerate and herniated lumbar disc: clinical and neuroradiological outcome

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Aim. **Lumbar disc herniation associated with back pain is often related to disc degeneration. Back pain after microdiscectomy often persists, prejudicing clinical outcome and quality of life. To this day, the evolution of disc degeneration after classical microdiscectomy has never been proven. Percutaneous dynamic stabilization after microdiscectomy has been proposed as a novel surgical strategy for treatment of back pain with herniated disc. However, clinical results are still debated and no evidences about the long-term evolution of back pain and relationships between neuroradiological imaging and clinical outcome have been provided. We report our preliminary observations concerning the clinical and neuroradiological outcome of 11 patients treated with microdiscectomy and dynamic percutaneous lumbo-sacral stabilization, after a long-term follow-up (2-years).**

Methods. **This was an uncontrolled case series. The study included 11 patients (3 F, 8 M) with L5-S1 discal herniation and degeneration underwent microdiscectomy and percutaneous dynamic stabilization, from December 2008 to November 2009. All the patients were symptomatic with back and leg pain non-responsive to long-term (8-12 months) medical and physical treatments. VAS and Satisfaction Index were used, respectively, for evaluation of clinical outcome and general postoperative patients' satisfaction. Modic and Pfirrmann scores were used for evaluation of neuroradiological outcome. All the patients underwent to microdiscectomy and implantation of the same percutaneous device for dynamic stabilization of the middle vertebral column during the same surgery. Modic, Pfirrmann, VAS and Satisfaction Index scores were collected before surgery and over the follow-up (45 days, 1 and 2 years). MRI and dynamic X-Ray 2 years after surgery were compared to the preoperative imaging.**

Results. **Motion preservation at the functional spinal unit after surgery was demonstrated in all the cases. All patients reported a reduction or complete resolution of back and leg pain, they were satisfied and came back to normal socio-professional life. No modification of the preoperative Pfirrmann was observed, even in those patients who experienced restoration of back pain. No surgical complications nor device failures were reported.**

Conclusion. **Percutaneous minimally invasive lumbo-sacral dynamic stabilization after microdiscectomy seems a reliable and effective technique in order to obtain a resolution of back pain and seems to prevent the Pfirrmann worsening, over a long-term follow-up.**

Key words: Intervertebral disc degeneration - Back pain - Discectomy.

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Microdiskectomy is a common and reliable treatment for lumbar disc herniation after having failed conservative treatments. Early surgery improved the recovery rate of leg pain, but the 1-year outcome rates were similar for both early and late surgery.[1] At the two-year follow-up, surgery and non-operative approaches (including NSAIDs, steroids, drugs supplement, muscle relaxants, physical therapy and injective therapies) both demonstrated clinical improvement (the better results of surgery were not statistically significant).[2, 3] However, at the four-year-follow-up, surgery turned out to be better in terms of clinical outcome compared to alternative treatments.[2, 3]

Different classifications about lumbar disc degeneration have been proposed. Two of these are the most validated and commonly used. Firstly, the Modic classification of vertebral endplate changes that includes 3 progressive types of degeneration: type I, changes are hypointense on T1-weighted imaging and hyperintense on T2-weighted imaging (representing bone marrow edema and inflammation); type II, changes are T1-hyperintense and T2-isointense or slightly hyperintense (as result of marrow ischemia with conversion of normal red hemopoietic bone into the yellow fatty marrow); type III, changes are both T1 and T2 hypointense (as result of subchondral bone sclerosis). Secondly, the Pfirrmann score [4] including five grades of progressive degeneration: grade I, disc homogeneous, white hyperintense, normal height; grade II, disc inhomogeneous, white hyperintense, normal height; grade III, disc inhomogeneous, intermediate grey, normal or slightly decreased height; grade IV, disc inhomogeneous, dark grey, normal or moderately decreased height; grade V, disc inhomogeneous, black signal, collapsed space.

Recently, Rahme *et al.*[5, 6] emphasized how a number of patients, who had undergone a successful standard discectomy (with facet sparing and resection just of disrupted disc material) for lumbar disc herniation, developed progressive disc space degeneration classifiable by means of Modic algorithm for endplate changes[7-9] over a median follow-up of 41 months (range 32-59 months). Particularly Rhame *et al.* described Modic changes in 46.3% of their population before surgery and in 78% at the last follow-up; the prevalence of Modic type II was 63.4% in this case series. Moreover, the authors reported a trend for Modic I to progress into type II, but they did not observe impairment of Type II, also proposing a correlation between endplates changes and low back pain after surgery (by means of Oswestry Disability Index and Patient Satisfaction Index).[10-12] Other authors described the role of dynamic stabilization in order to prevent the progression of degenerative endplates changes after discectomy and to improve the post-operative discal restoration.[13-15]

We treated 11 patients with a percutaneous and completely reversible device and lumbar discectomy for degenerated and herniated disc, in order to prevent further discal degeneration. We analyzed and discussed the clinical and neuroradiological outcome after a long-term two-year follow-up.

Materials and methods

From December 2008 to November 2009, eleven patients (3 F, 8 M; aging 20-61 years) underwent

Figure 1.—Preoperative MRI: sagittal T2 sequence, showing L5-S1 disc degeneration with herniation and endplates modifications.

L5-S1 microdiscectomy after dynamic percutaneous stabilization, at the same surgery, for discal herniation associated-with discal degeneration.

The preoperative MRI revealed a left discal herniation in 3 patients and a right discal herniation in the other 8 cases.

Both the discal herniation and the degenerated disc were symptomatic with leg and back pain, respectively. All the patients were non responders to 8-12 months non-operative treatment including NSAIDs, steroids, drugs supplement, muscle relaxants, rehabilitation and injective therapies.

All the patients underwent dynamic X-ray films (in order to test the motion preservation of the L5-S1 functional spinal unit) and to MRI (Philips, 1.5 Tesla images T1-T2 weighed Turbo Spin Eco, also with Short Tau Inversion Recovery sequences) in order to disclose discal degeneration and/or herniation and possible degeneration and/or deformation of the articulations according to the Fujiwara classification [16] (Figure 1). Modic and Pfirrmann MRI preoperative changes were collected in every patient before surgery. Visual Analogue Scale (VAS) scores for pain were also collected before surgery. In none of the patients there was a preoperative neurological deficit.

In all the cases we performed a percutaneous dynamic stabilization with a PercuDyn system™ (Interventional Spine Inc., Irvine, CA, USA) device and by using radiological intraoperative fluoroscopic monitoring. We preferred to perform the microscopic discectomy after the dynamic stabilization, in order to preserve the anatomical entry points for the percutaneous procedure.

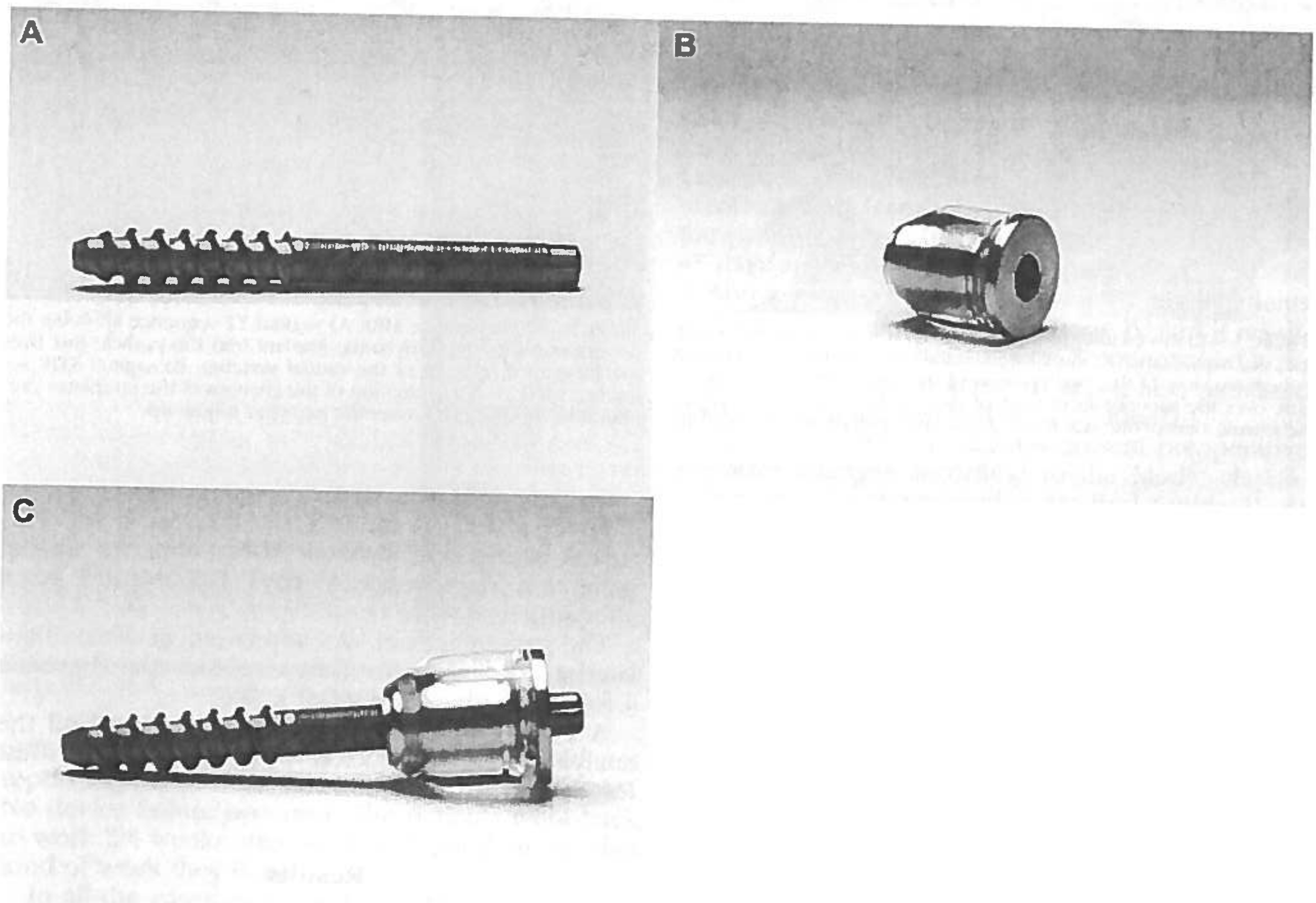

Figure 2.—This picture shows the two elements of the device. A) the pediculate screw; B) the bell; C) final assemblage: the screw after the insertion within the bell.

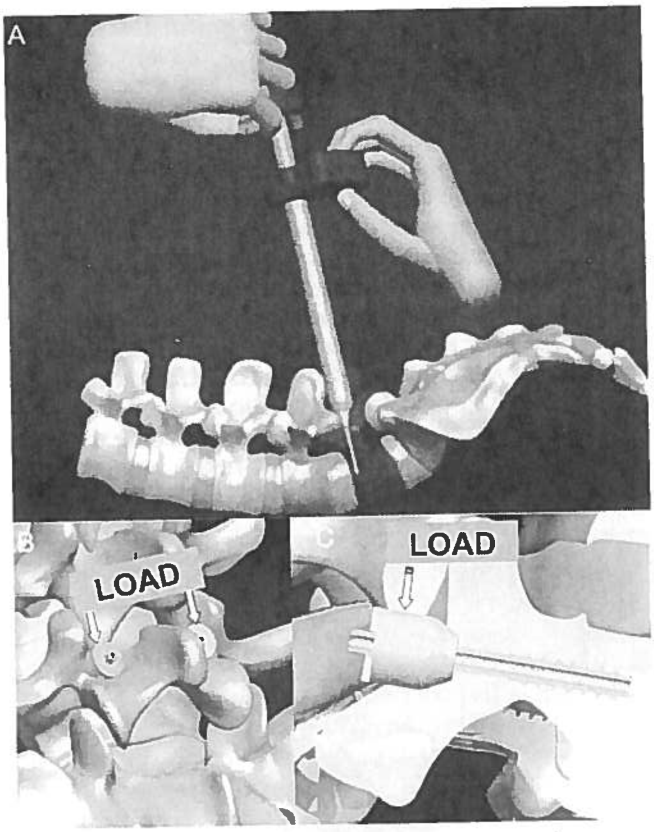

Figure 3.—In this picture: A) a schematic representation of the percutaneous implantation of the dynamic stabilization system; B) a coronal schematic view of the final position of the screws into the pedicles, just over the superior facet joint of the caudal vertebra; C) sagittal schematic view of one side screw in the final position into the pedicle.

Figure 4.—Postoperative MRI: A) sagittal T2 sequence showing the correct position of the dynamic implant into the pedicle just over the superior facet joint of the caudal vertebra; B) sagittal STIR sequence used for the evaluation of the changes of the endplates preoperative modifications over the two-year follow-up.

The PercuDyn system™ (Interventional Spine Inc.) is a percutaneous device for dynamic stabilization of the middle vertebral column which is composed of 2 elements:[14] one is a titanium pediculate screw (length: 38 mm; diameter: 4.5 mm) and the other is a polycarbonate-urethane shock absorber bell (Figure 2).

After the percutaneous placement of the screws using a dedicated instrumentation and a fluoroscopic intraoperative guide, the bell is located and fixed in a special point of the screw and carefully located between the L5-S1 articulation (Figure 2C), in order to give a dynamic stabilization of the middle vertebral column and an assistance to the motion of the spinal functional unit–in order to have a "cushion" effect at the same time (Figures 3, 4).

VAS, Satisfaction Index Test, MRI, Modic and Pfirrmann scores and dynamic X-ray films for all the patients were collected 45 days, 1 year and 2 years after surgery (Table I).

The percentages of VAS improvement were calculated according to the following formula: (baseline – follow-up)/baseline score X 100.

A $P<0.05$ was considered significant and all the analyses were conducted with a Two Sided Test (MedCalc© statistical software).

Results

All the patients started to walk again 3-4 hours after surgery and were discharged the following

TABLE I.—*Back pain VAS, Modic and Pfirrmann Scores before surgery and at 1- and 2-year follow-ups.*

Patient N.	Preoperative			One-year follow-up			Two-year follow-up			
	VAS	Modic	Pfirrmann	VAS	Modic	Pfirrmann	VAS	Modic	Pfirrmann	VAS improvement
1	7	0	4	3	0	4	3	0	4	57 %
2	6	0	4	0	0	4	0	0	4	100 %
3	9	0	3	0	1	3	0	1	3	100 %
4	6	1	3	0	1	3	0	1	4	100 %
5	5	0	3	0	1	3	0	1	3	100 %
6	7	0	3	0	0	3	0	0	3	100 %
7	8	0	3	0	1	3	0	1	3	100 %
8	7	0	3	0	1	3	0	1	3	100 %
9	8	1	4	0	2	4	0	2	4	100 %
10	8	0	3	0	1	3	0	1	3	100 %
11	8	0	3	2	1	3	2	1	3	75 %

The percentages of VAS score improvement at the two-year follow-up are also reported.

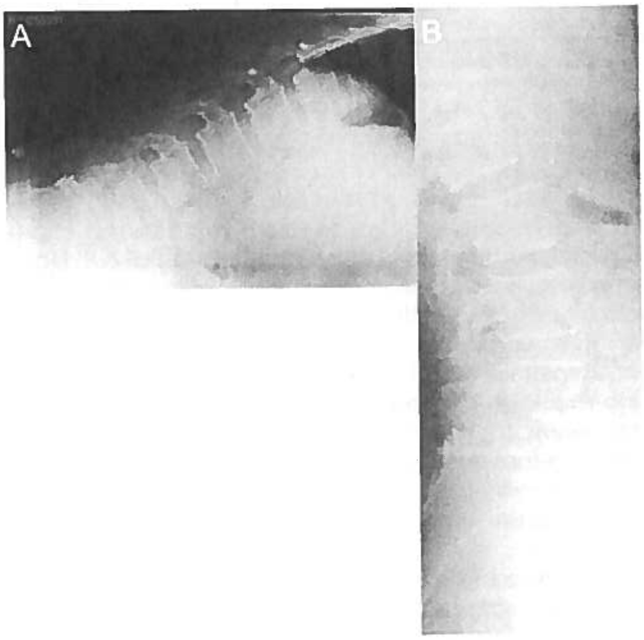

Figure 5.—The post-operative dynamic X-rays film shows the good range of motion 2 years after the operation.

morning, without external orthesis. We could not report any kind of complications in this case series. No device failure occurred. The patients went back to work 2-4 weeks after surgery, depending on what kind of work they have.

In all the cases dynamic X-rays showed the preservation of the motion of the operated functional spinal unit 45 days after surgery as well as at the last follow-up after 2 years (Figure 5). Neither discal herniation recurrences nor fibrosis were reported all over the follow-up. Leg pain was completely solved in all the cases and the patients experienced a significant and satisfactory improvement in the VAS score for their backache (Table I). The mean VAS improvement was 94% (range 54-100%) (Table I). Finally, all the patients were satisfied both at the control after 45 days and at the last follow-up.

About the neuroradiological outcome, 3 patients had a preoperative Pfirrmann grade IV and it resulted steady 2 years after surgery; 8 patients had a preoperative Pfirrmann grade III and it also remained unchanged at the last follow-up (Table I).

Nine of the patients did not present preoperative endplate changes according to the Modic classification and 2 patients had a Modic I (Table I). At the last follow-up we observed: modifications from non-Modic degeneration to Modic I in 6 patients; 1 patient changed from preoperative Modic I to Modic II; 1 patient remained Modic I; 3 cases without preoperative endplate degeneration according to the Modic classification were unchanged at the last follow-up (Table I).

The VAS score improvement for back pain resulted statistically significant in all the follow-ups (Figure 6).

We did not find any significant statistical trend between Modic changes and back pain improvement in all the follow-ups. The statistical analysis of the Pfirrmann grade modification did not appear significant, either compared to the back pain VAS improvements.

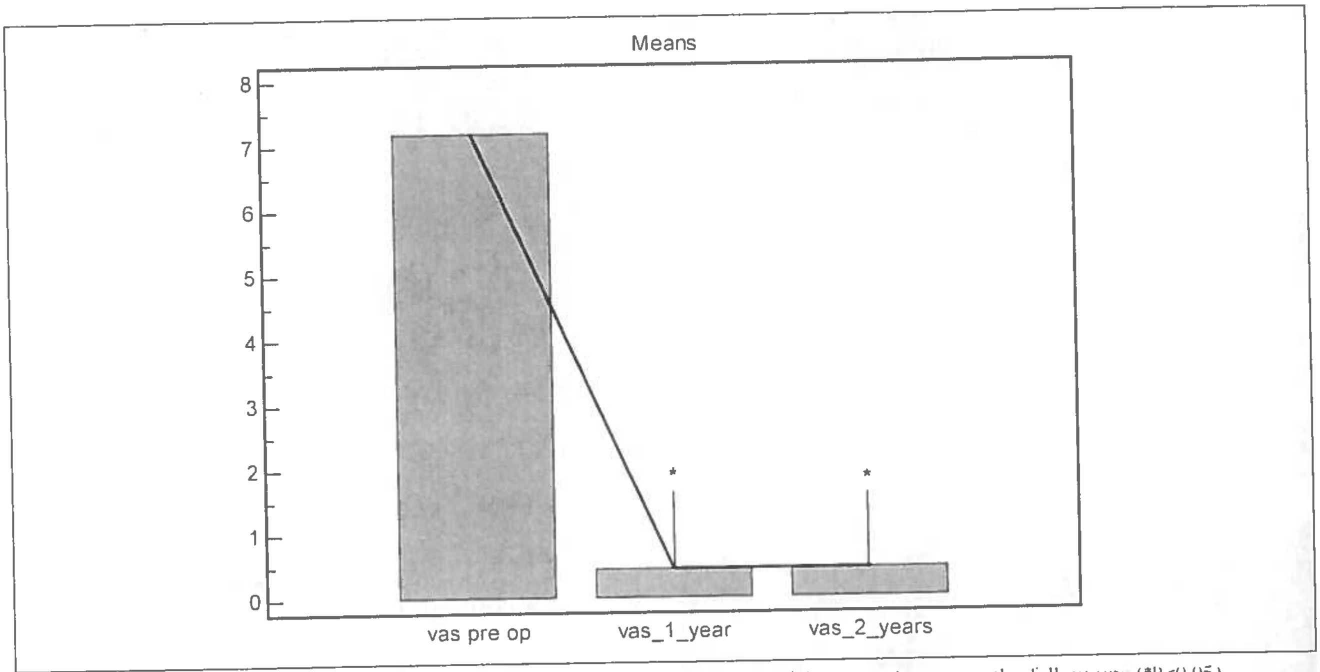

Figure 6.—The results of the statistical analysis regarding the VAS improvement of the 11 patients over the follow-ups (*P<0.05).

Discussion

The Modic classification of vertebral endplate changes includes 3 progressive types of degeneration: type I (changes are hypointense on T1-weighted imaging and hyperintense on T2 – weighted imaging, representing bone marrow edema and inflammation); type II (changes are T1-hyperintense and T2-isointense or slightly hypeintense, as a result of marrow ischemia with conversion of normal red hemopoietic bone into the yellow fatty marrow); type III (changes are both T1 and T2 hypointense (representing subchondral bone sclerosis). There are 2 theories about the etiopathology of Modic changes. The first one (biomechanical) was proposed by Modic:[7, 8] abnormal stresses on the endplate and the microenvironment of adjacent vertebral bone marrow produce histological changes, reflecting intensity changes on MR imaging. The second one (biochemical) was proposed by Crock [17, 18] who suggested that the inflammatory reaction caused by toxic substances from the degenerated disc could progressively produce Modic changes.

The natural history of Modic changes is characterized by the conversion of Type I (unstable) into Type II (more stable) after 18-24 months.[7, 8, 19] However, the clinical role of Modic changes still remains unclear. A recent literature review, in fact, suggests a high variability of association between different types of Modic changes and different levels of low back pain. Moreover, Modic classification does not seem to have a prognostic value in predicting post-operative clinical and neuroradiological outcome.[10, 11, 17, 18, 20]

Pfirrmann also developed a classification system for lumbar disc degeneration [1] based on routine T2-weighted MR images, by means of an algorithm resulting from the merging between literature data about lumbar degenerative disc and data provided by the review of lumbar MRI examinations collected in routine clinical practice. Three-hundred lumbar intervertebral discs, 60 patients (33 M, 27 F), mean age 40 (range 10-83 years). Three different observers analyzed all the scans independently. Intra- and interobserver reliabilities were assessed by calculating kappa statistics.

Five grades of progressive degeneration were defined: grade I, disc homogeneous, white hyperintense, normal height; grade II, disc inhomogeneous, white hyperintense, normal height; grade III, disc inhomogeneous, intermediate grey, normal or slightly decreased height; grade IV, disc inhomogeneous, dark grey, normal or moderately decreased height; grade V, disc inhomogeneous, black signal, collapsed space.

The report from Rhame *et al.*[6] about Modic changes and "shifting" after discectomy alone does not differ from the natural history of Modic changes without surgery. After surgery the most frequent conversion reported was from Type I (Unstable) to Type II (more stable), such as in the natural history of Modic changes. The authors also proposed an interesting inverse correlation between the progression of Modic changes and the development of low back pain after surgery. They observed, in fact, a progression of degenerative vertebral body endplate changes after discectomy in patients who did not experience low back pain. Finally, It is worth noting that the authors did not observe any reverse conversion to Type 0 and that they reported the following modifications in their 22 patients with no preoperative Modic changes: 4 cases of conversion to Modic I and 9 cases of conversion into Modic II.

Other interesting elements of discussion are reported by Putzier *et al.*[15] and by Cho *et al.*[13] The first author suggested that dynamic stabilization may prevent progression of the degenerative endplate changes after lumbar discectomy. The second author described a case of lumbar disc rehydration after the implantation of a posterior dynamic stabilization system. Particularly, Cho emphasized the crucial role of the physiological motion load distribution and of the intra-discal pressure for the disc viability. Since a degenerated disc does not regenerate on its own, external dynamic devices may provide an optimal condition for such regeneration, controlling the range of motion and absorbing the non-physiological overloads.

Considering the literature, the discectomy without the instrumentation of a lumbar disc with pre-operative non-Modic degeneration seems more prone to a post-operative change into Modic I or II. Moreover, the preoperative Modic I is more prone to change into Modic II if discectomy without instrumentation is performed. Finally, no inversion from Modic I or II to non-Modic changes seems frequent in those cases where discectomy without instrumentation is performed. Discectomy with dynamic stabilization seems to prevent the impairments of Modic endplate changes, thus supporting discal restoration.[6, 15, 13]

We decided to use a percutaneous minimally invasive and completely reversible device (PercuDyn™) for L5-S1 space. At this level, in fact, it is not always possible to use dynamic interspinous /interlaminar devices (because of the anatomical aspect of the S1 spinal process) and dynamic stabilization by means of L5-S1 pedicular screws and rods which are, definitely, more invasive.

In our case series, all the patients experienced an improvement in post-operative VAS all over the follow-up. The back and leg pain improvement resulted statistically significant in all the patients. On the contrary, the Modic changes we observed did not correlate positively with the clinical outcome. In 7 patients, in fact, the Modic type worsened and in 4 patients it resulted unchanged (Table I), in respect to the pre-operative imaging, event if all these patients experienced a complete or dramatic pain reduction and came back to normal socio-professional life. However, these data resulted not statistically significant perhaps in reason of the small case series.

In our case series, preoperative back pain was associated with Pfirrmann grade III/IV. Differently from Modic changes, the post-operative MRI, at the last follow-up, did not show any modification of the Pfirrmann grades (Figure 4), in spite of the complete resolution or good recovery of back pain (Table I). Pfirrmann III and IV seem, in this short series, potential indicators of neurological instability when related to pre-operative back pain. These results suggest that the dynamic stabilization after microdiscectomy could solve the instability producing a good recovery or resolution of back pain without any modification of the Pfirrmann grade.

Finally, considering our experience, the percutaneous approach and dynamic stabilization seem more valid in order to reduce the surgical impact on the anatomical muscle structures.

Conclusions

Our long-term follow-up compared to literature data suggests a potential role of dynamic stabilization after microdiscectomy in patients with: pre-operative Pfirrmann III/IV, good pre-operative range of motion (tested by dynamic X-ray films), preoperative integrity of vertebral articulate processes (verified by MR imaging), preoperative back pain (non responding to long-term medical and physical treatments). Even if our data need of a RCT and further confirmation (larger case series, longer follow-up) dynamic stabilization seems producing complete or good low back pain recovery and full motion preservation up to two-years after surgery.

Of course, the improvement in knowledge of biomechanics and biochemistry of the intervertebral lumbar disc, new imaging technologies such as 23-Na-Double Quantum Filtred NMR Spectroscopy [21, 22] and Axial T2 Mapping [23] may give an effective support to magnify the role of the endplate and discal height changes after simple discectomy and discectomy plus dynamic stabilization, in order to improve the knowledge about correlations between back pain and disk degenerations and about factors predicting surgical outcome.

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Conflicts of interest.—The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Received on November 14, 2012.
Accepted for publication on October 18, 2013.