Ultra-long-term outcome of surgically treated far-lateral, extraforaminal lumbar disc herniations: a single-center series

Gerhard Marquardt · Markus Bruder ·
Stephanie Theuss · Matthias Setzer ·
Volker Seifert

Received: 7 June 2011 / Revised: 28 November 2011 / Accepted: 7 December 2011 / Published online: 17 December 2011
© Springer-Verlag 2011

Abstract

Purpose Far-lateral extraforaminal lumbar disc herniation is an uncommon cause of nerve root entrapment, and studies addressing the long-term outcome of surgically treated patients are few. The purpose of this study was to analyze the ultra-long-term outcome of patients who were treated via a lateral approach.

Methods The medical reports of 138 consecutive patients were analyzed with regard to signs and symptoms, operative findings, complications, and short-term outcome (6 weeks). To assess long-term results, standardized telephone interviews were performed using a structured questionnaire. The patients were questioned about pain using the verbal rating scale and persisting symptoms, if any. Other queries were related to the Oswestry Disability Index. Subjective satisfaction with the result of surgery was classified as excellent (no pain), good (some pain), fair (moderate pain), and poor (unchanged or worse) based on MacNab classification.

Results At short-term follow-up, major and moderate leg pain had decreased from 99.3 to 5.1% and low back pain from 97.8 to 2.8%. Sensory and motor deficits, however, were still present in the majority of patients. A total of 87 telephone interviews were conducted, and the mean follow-up was 146 months. As many as 49 patients (56.3%) reported complete relief of symptoms, 14 patients (16.1%) had minor ailments under physical stress, and 24 patients (27.6%) had permanent residual symptoms. The most common complaint was remaining sensory disturbance.

Despite residual symptoms, the vast majority of patients expressed satisfaction with the result of surgery. The outcome was subjectively rated as follows: 75.9% excellent (66 patients), 18.4% good (16 patients), 4.6% fair (4 patients), and 1.1% poor (1 patient).

Conclusions The lateral approach is a minimally invasive and safe procedure with low complication rates. The profit from surgery is maintained beyond the usual postoperative observation periods. Thus, ultimate outcome at ultra-long-term follow-up is very gratifying in the vast majority of patients.

Keywords Far-lateral disc herniation · Extraforaminal disc herniation · Lumbar disc herniation · Paraspinal approach · Lateral approach

Introduction

Compared to “classical” disc herniations that protrude mediolaterally into the spinal canal, far-lateral extraforaminal lumbar disc herniation (FELDH) is a rather uncommon feature of degenerative lumbar disc disease. It accounts for approximately 7–12% of all lumbar disc herniations depending on the respective clinical case series. Even though surgical therapy via a lateral paraspinal muscle-splitting approach has proved to be a safe and minimally invasive method with excellent results, its realization is more demanding owing to its less familiar route and the absence of the usual anatomical landmarks known from medial approaches.

To obtain significant long-term results, a follow-up period of at least 4 years after surgery for lumbar disc herniation has been proposed [6]. Whereas true long-term results are available for mediolateral disc herniations [25],

G. Marquardt (✉) · M. Bruder · S. Theuss · M. Setzer ·
V. Seifert
Neurosurgical Clinic, Johann Wolfgang Goethe-University,
Schleusenweg 2-16, 60528 Frankfurt am Main, Germany
e-mail: G.Marquardt@em.uni-frankfurt.de

the vast majority of publications pertaining to FELDHs do not meet this suggestion. Most of the studies investigate short- and medium-term results after surgical therapy, and there are only few studies that address the long-term outcome of surgically treated FELDHs. These studies, covering follow-up periods between 4 and 8 years, indicate gratifying success rates in about 80% of patients.

The purpose of the present study was to investigate whether a benefit from surgery was also maintained at ultra-long-term follow-up and whether the ultimate outcome of patients was favorable. For this reason, we analyzed the outcome of patients with FELDH who were treated via a lateral approach at our institution. The mean follow-up was 12.2 years.

Patients and methods

The clinical data of 138 consecutive patients who underwent operation for FELDHs between 1989 and 2008 at our institution were retrospectively obtained by reviewing medical reports and outpatient charts. There were 75 men (54.3%) and 63 women (45.7%), with an average age of 56 years (range 22–80 years). The records of each patient were analyzed with respect to clinical signs and symptoms, operative findings, surgery-related complications, and short-term outcome (6 weeks). To assess the ultra-long-term results, standardized telephone interviews were performed, which were completed by the author not involved in surgery (S.T.). For this purpose, a structured questionnaire was designed to attain precise indications about each patient's potential residual complaints. To record the possible presence of back pain and/or sciatica, the patients were queried about pain using the verbal rating scale (VRS, 0 = no pain, 10 = maximum pain). Furthermore, the patients were asked for persisting sensory and/or motor disturbances, if any. Other information concerned physical capacity, potential restrictions in activities of daily living, and resumption of work. Questions related hereto were based on the Oswestry Disability Index (ODI) [10]. Subjective satisfaction with the result of surgery was classified as excellent (no pain), good (some pain), fair (moderate pain), and poor (unchanged or worse) based on MacNab classification [15].

Surgical procedure

For performing the surgery, a minimally invasive lateral approach was used. Following a 4-cm long, horizontal skin incision 3 cm lateral to the midline, the fascia was incised longitudinally. The approach proceeded bluntly into the depth by digital preparation and separation of the multifidus and longissimus muscles along the natural septa. Once

the transverse process and the lateral facet joint were reached, self-retaining retractors were inserted and the operating microscope was brought into place. Only in few cases, minor resection of bone to expose the yellow ligament was necessary. The ligament was opened and, thus, root, ganglion, and herniated disc were visualized directly. Typically, the nerve root was dislocated cranially by the herniated disc. Removing of all herniated disc material resulted in decompression of the root and ganglion. If considered necessary, the disc space was entered and partially emptied; however, it was not cleared routinely. Finally, the wound was closed in layers in the usual fashion.

Results

Preoperative findings

FELDH was located at the level of L2–3 in five patients (3.6%), L3–4 in 46 (33.3%), L4–5 in 56 (40.6%), and at the L5–S1 level in 31 (22.5%) patients. The mean duration of symptoms was 6.2 weeks. On admission, all patients but one (99.3%) suffered from leg pain, either of the femoral or sciatic type, and 96.4% of the patients complained of low back pain. A positive straight leg raising sign was found in 64.5% of the patients, and reverse Lasègue's sign was positive in 8.0% of cases. As much as 79.0% of the patients ($n = 109$) had sensory deficits of the monoradicular dermatomal distribution, and in 71.7% ($n = 99$) paresis of the reference muscles of the affected spinal nerve root was present. None of the patients had vegetative dysfunction.

Intraoperative findings

In more than two-thirds of the patients ($n = 97$), a frank extrusion with free fragments of disc material was found, in 29.0% ($n = 40$) it was a subligamentous disc herniation. In one patient, merely a protrusion exerting pressure onto the nerve root was encountered. These intraoperative findings did not have any impact on postoperative outcome.

Postoperative findings

Short-term follow-up revealed that 97 (70.8%) of those 137 patients complaining of leg pain before surgery were completely pain free after surgery, while 33 patients (24.1%) reported of some leg pain. Thus, the incidence of major and moderate leg pain decreased from 99.3 to 5.1%. Low back pain similarly declined from 97.8 to 2.8%, as 103 of 133 patients (77.4%) with low back pain preoperatively were pain free after surgery and another 26 (19.5%) reported significant reduction. Sensory deficits, on the other

hand, did not disappear so impressively. Even though no longer present in 19 patients (17.4%), they were still detectable in the majority of cases: 56 patients (51.4%) showed some improvement and in 34 (31.2%) they were unchanged. Similar short-term results apply to motor deficits: 20 patients (20.2%) had no paresis, 56 (56.6%) showed amelioration, and the remaining 23 were unchanged.

To conduct the patient survey for assessment of ultra-long-term results as comprehensively and completely as possible, an intensive search for the patients was carried out. A total of 41 patients were lost to follow-up due to moving, while 97 (70.3%) could be located. An interview, however, was not realized in ten patients: seven had deceased already, two could not provide any information due to dementia that had emerged in the meantime, and one patient refused participation in this study. Thus, a total of 87 complete telephone interviews accounting for a respondent rate of 63.0% were conducted. The mean follow-up was 146 months (range 18–238 months).

In this survey, 49 patients (56.3%) reported complete relief of symptoms. Fourteen patients (16.1%) indicated minor ailments exclusively under physical stress, and 24 patients (27.6%) complained of permanent residual symptoms of a different kind and intensity. The most common complaint was remaining hypesthesia and paresthesia as indicated from 37 patients (42.5%); 22 patients (25.3%) mentioned some enduring weakness. Some radicular pain was noted by 19 patients (21.8%) as was low back pain by 10 patients (11.6%), both most commonly under physical strain. Nevertheless, despite residual symptoms, the vast majority of patients expressed satisfaction with the result of surgery. Based on MacNab classification, the subjectively rated long-term results were as follows: 75.9% excellent (66 patients), 18.4% good (16 patients), 4.6% fair (4 patients), and 1.1% poor (1 patient).

Of the 87 patients, 54 (62.1%) were gainfully employed before surgery, while the other patients were pensioners, housewives, or unemployed. After surgery, 39 patients (72.2%) remained in their previous occupation, 4 (7.2%) were retrained and changed jobs. Nine patients (16.7%) applied for a certificate of disability and two stopped working for private reasons.

Postoperative complications

Postoperative complications were observed in three patients (2.2%). One patient developed a seroma in the wound area and another patient a hematoma. Both patients could be treated conservatively and made an uneventful recovery. The third patient developed a wound healing disorder requiring surgical revision, and the subsequent course was also uneventful.

Recurrence

During their stay in hospital, eight patients (5.8%) complained of persisting ($n = 3$) or recurrent ($n = 5$) radicular pain. In all of them, subsequent MRI revealed sequestered disc material compressing the nerve root that had to be removed by a second procedure. However, a reliable distinction between residual sequester and ultra-early recurrence was not possible. Outcome after revision surgery was excellent in five patients and good in three.

Among the patients followed, there were further seven recurrences (8%) during follow-up, with disc herniations at the same level and same extraforaminal location. Five recurrences developed during the 1st postoperative year, and two patients experienced relapse after 2 and 14 years, respectively. Following re-operation, the outcome was excellent in four patients (57.1%) and good in three (42.9%) at further follow-up.

Discussion

FELDH is a rather uncommon condition of nerve root entrapment accounting for 7–12% of all lumbar disc herniations. It may compress the nerve root outside the vertebral canal and in its extraforaminal course. Clinical syndromes reflect compression of the superiorly exiting nerve root, i.e., at the level of L4–5, an L4 root syndrome is produced [9]. Whereas neurological deficits, if present, parallel those found in “classical” disc herniations that protrude mediolaterally into the spinal canal, the pain evoked by FELDH is most often particularly severe and sometimes even excruciating. This striking feature is caused by a direct compression of both the nerve root and the spinal ganglion, which is an extraordinarily pain-sensitive structure.

Surgical approach

Various surgical approaches have been proposed for the surgical treatment of FELDH. Interlaminar midline approaches with laminectomy, laminotomy, hemilaminectomy, and subtotal or full facetectomy have been recommended as well as lateral procedures and endoscopic approaches. The lateral paraspinal muscle-splitting approach that has been used in our patients is a safe and minimally invasive method. To reach the foraminal and extraforaminal space, resection of bone or parts of the facet joints is almost never necessary. On opening the ligamentous structures, the herniated disc material and both the compressed ganglion and nerve root are visualized directly. This is quite in contrast to midline approaches where extensive bone resection is unfailingly required to reach

FELDHs. Even though the development of spinal instability after unilateral complete facetectomy is stated to be rather unusual, nevertheless, its occurrence has been reported [9, 11, 14, 24]. Furthermore, these extensive approaches may contribute to continued postoperative discomfort. A comparison of the lateral and medial approach demonstrated significantly better results for the lateral approach [9, 21]. Its surgical realization, however, is more demanding owing to its less familiar route and the absence of the usual anatomical landmarks known from medial approaches. Thus, an adequate training is required to gain a detailed understanding of the anatomy of the paraspinal area and to get well acquainted with this approach.

Clinical results

To obtain significant long-term results, a follow-up period of at least 4 years after surgery for lumbar disc herniation has been proposed [6]. Most of the publications pertaining to FELDHs, however, investigate short- and medium-term results with postoperative observation periods of <4 years or even <2 years. Only a handful of papers have been published so far that concern the long-term results of surgically treated FELDHs (Table 1). In this context, the presented study features the longest postoperative observation period to the best of our knowledge with a mean follow-up of 12.2 years.

The results of published short-term studies with a follow-up of <2 years show consistently high success rates. Siebner reported 85% excellent and good results after a mean follow-up of 9.5 months. However, one of his 40 patients treated via a medial foraminectomy needed a secondary spinal fusion procedure [24]. O'Hara found excellent and good results in 90% of his 20 patients after 14 months [16], and in the same period of time all 13 patients of Gioia were pain free [12]. Performing a medial approach, Garrido reported 92% excellent and good results after nearly 2 years. Spinal fusion was required in one of his 41 patients after complete facetectomy [11].

Regarding the medium-term outcome with a follow-up of 2–4 years, similarly positive results are indicated. Irrespective of the approach, more than half of the published studies report an excellent or good outcome in more than 90% of patients [3, 8, 14, 20, 22]. Slightly less favorable results were presented by Chang. After a mean follow-up of 38.4 months, he found excellent and good outcomes in 78.3% of his 184 patients who were treated via a lateral approach [2]. Similar results with this approach were reported by Vogelsang [26] and Donaldson [8], who performed a medial approach. Remarkable in this regard is the study carried out by Ryang and colleagues. Performing a lateral approach, they achieved 95% good or excellent

results, whereas merely 57% of their patients had such a positive outcome if treated with a medial procedure [21]. Also noteworthy is the study performed by Kunogi. He reported an excellent or good outcome for all of his eight patients. Two of his patients, however, required spinal fusion after complete facetectomy [14].

Up to now, there are only four studies to the best of our knowledge that address the long-term outcome with follow-up periods of more than 4 years. Porchet, evaluating the largest series of patients after 4.2 years, found excellent and good outcomes in 73% of his 202 patients [19]. More favorable are the reports of Weiner [27] and Ozveren [18] with excellent and good results in 85 and 100%, respectively, of their patients after 5–8 years. Epstein, comparing different surgical procedures, found excellent and good results after 5 years ranging from 68 to 79%. Again, better results were obtained using the lateral approach [9].

The results of the present series show comparably gratifying results at ultra-long-term follow-up, as 94.3% of the patients rated their outcome as excellent or good. When evaluated according to the responses to the questionnaire, however, the success rates were lower. Nonetheless, despite partly residual symptoms, the patients' satisfaction with the result of surgery was high. This means that the subjective contentment was significantly higher than complete relief (56.3%). The reason for these diverging results might be seen in the fact that the patients felt barely affected by the most common residual complaints, i.e., sensory deficits and mild paresis. More important for them appeared to be the freedom from pain which was complete, however, in only two-thirds of the patients. Still, 21.8% of the patients reported some radicular pain and 11.6% low back pain. Most of these patients were satisfied with the outcome, nevertheless, because the intensity of pain had decreased significantly or pain emerged solely under physical strain. Since the median postoperative observation period was 12.2 years, the provided data demonstrated that the profit from surgery was maintained also at ultra-long-term follow-up. Furthermore, it could be shown that the ultimate outcome was positive in the vast majority of cases.

Complications and recurrences

Our rate of complications (2.2%) is in line with the provided data of other studies. Porchet indicated 1.5% minor complications related to surgery [19], and Salame reported two dural tears without any clinical sequelae accounting for a complication rate of 6.5% [22]. A similar complication rate of 5% was found by Ryang, when a lateral approach was performed. It was 11%, however, if the patients were treated via a medial approach [21]. This means that complications are apparently more than twice as often with medial procedures. More serious were the complications

Table 1 Summary of outcome studies

Author/reference	No. of pat	Operative approach	Mean follow-up	Outcome
Short-term follow-up studies (<2 years)				
Siebner and Faulhauer [24]	40	Lat and med	9.5 months	85% excellent or good, spinal fusion in one pat after medial foraminectomy
Sasani et al. [23]	66	Lat endo	12.0 months	86.4% excellent and good
O'Hara and Marshall [16]	20	Lat	14.0 months	90% excellent or good
Gioia et al. [12]	13	Lat	14.0 months	100% excellent
Hodges et al. [13]	25	Lat	22.3 months	Significant pain reduction, improved functional capacity
Garrido and Connaughton [11]	41	Med	22.4 months	92% excellent or good, spinal fusion in one pat after complete facetectomy
Medium-term follow-up studies (2–4 years)				
Salame and Lidar [22]	31	Lat	25.2 months	All patients had improvement for radicular and back pain
Donaldson et al. [8]	25	Med	30.3 months	72% excellent or good
Kunogi and Hasue [14]	8	Lat and med	30.0 months	100% excellent or good, spinal fusion in two cases after complete facetectomy
Vogelsang and Maier [26]	73	Lat	30.4 months	74% excellent or good
Quaglietta et al. [20]	42	Lat	32.5 months	91% excellent or good
Choi et al. [3]	41	Lat endo	34.1 months	92% excellent or good
Ryang et al. [21]	48	Lat and med	36.5 months	95% excellent or good (lat appr); 57% excellent or good (med appr)
Chang et al. [2]	184	Lat	38.4 months	78.3% excellent or good
Darden et al. [5]	31	Lat	42.4 months	80% excellent and good
Long-term follow-up studies (>4 years)				
Porchet et al. [19]	202	Lat	50 months	73% excellent or good
Epstein [9]	170	Lat and med	5 years	79% excellent or good (lat appr); 69% excellent or good (med appr)
Weiner and Dabbah [27]	60	Lat	5.5 years	85% excellent and good
Ozveren et al. [18]	18	Lat	5–8 years	100% excellent
Present series (2011)	87	Lat	12.2 years	94.3% excellent and good

The studies are ordered according to their length of follow-up

Pat patients, lat lateral, med medial, endo endoscopic, appr approach

reported by Sasani [21]. In two (3%) of his endoscopically treated 66 patients, the nerve roots were partially damaged, and in another two the nerve roots were impinged by the working channel. These four patients had dysesthesia from just after surgery to a mean of 45 days after surgery. A persistent minimal paresis of the quadriceps femoris muscle and hypesthesia of the L4 dermatomal area were reported for those patients with partial root damage. All in all, however, complications were rather few and if present mostly without further negative consequence for the patients.

In our series, there were eight early (5.8%), and among the patients followed, seven further recurrences (8%) meaning a recurrence rate of 15/138 (10.8%).

On assumption that those patients who were not followed had also reherniations at the same rate, a further four patients should be counted, giving a total rate of 19/138,

i.e., 13.7%. Of the seven patients with recurrences during follow-up, five developed relapse during the first postoperative year. Similar results were found by Porchet. He observed 14 recurrences accounting for a recurrence rate of 7%, of which nine occurred <1 year after surgery [19]. This means that recurrences beyond the first year after surgery are obviously rather seldom.

Limitation of the study

Apart from its retrospective design, a limitation of this study might be that telephone interviews were employed. These telephone interviews on which our results rely of course cannot replace objective findings of a physical examination. Particularly, degrees of paresis and precise areas of sensory disturbances cannot be objectively evaluated this way. Hence, the validity of our results seems to

be limited since they are based on subjective estimations of the patients. However, for assessment of pain, the VRS, which is a modified form of the acknowledged visual analogous scale (VAS), was used. A comparison of results obtained with both the VRS and the VAS showed a good correlation between both scales. Thus, the VRS is a good alternative for oral surveys and interviews [4, 17]. Furthermore, the ODI, which is the most common method to investigate restrictions in daily life due to back pain [1, 7], was applied. We feel that by using a structured questionnaire based on acknowledged rating scales, it is possible, nonetheless, to obtain valid ultra-long-term results.

Conclusion

The lateral approach for the operative treatment of far-lateral, extraforaminal lumbar disc herniations is a minimally invasive and safe procedure with low complication rates. The profit from surgery is maintained beyond the usual postoperative observation periods. Thus, ultimate outcome at ultra-long-term follow-up is very gratifying in the vast majority of patients.

References

- Bombardier C (2000) Outcome assessments in the evaluation of treatment of spinal disorders: summary and general recommendations. *Spine (Phila Pa 1976)* 25:3100–3103
- Chang SB, Lee SH, Ahn Y, Kim JM (2006) Risk factor for unsatisfactory outcome after lumbar foraminal and far lateral microdecompression. *Spine* 31:1163–1167
- Choi G, Lee SH, Bhanot A, Raiturker PP, Chae YS (2007) Percutaneous endoscopic discectomy for extraforaminal lumbar disc herniations: extraforaminal targeted fragmentectomy technique using working channel endoscope. *Spine (Phila Pa 1976)* 32:93–99
- Cork RC, Isaac I, Elsharydah A, Saleemi S, Zavisca F, Alexander L (2004) A comparison of the verbal rating scale and the visual analog scale for pain assessment. *Internet J Anesthesiol* 8(1)
- Darden BV, Wade JF, Alexander R, Wood KE, Rhyne AL, Hicks JR (1995) Far lateral disc herniations treated by microscopic fragment excision. Techniques and results. *Spine* 20:1500–1505
- Davis RA (1994) A long-term outcome analysis of 984 surgically treated herniated lumbar discs. *J Neurosurg* 80:415–421
- Deyo RA, Battie M, Beurskens AJ, Bombardier C, Croft P, Koes B, Malmivaara A, Roland M, von Korf M, Waddell G (1998) Outcome measures for low back pain research. A proposal for standardized use. *Spine (Phila Pa 1976)* 23:2003–2012
- Donaldson WF 3rd, Star MJ, Thorne RP (1993) Surgical treatment for the far lateral herniated lumbar disc. *Spine (Phila Pa 1976)* 18:1263–1267
- Epstein NE (1995) Evaluation of varied surgical approaches used in the management of 170 far-lateral lumbar disc herniations: indications and results. *J Neurosurg* 83:648–656
- Fairbanks JE, Couper JC, Davies JB, O'Brien JP (1980) The Oswestry low back pain disability questionnaire. *Physiotherapy* 66:271–273
- Garrido E, Connaughton PN (1991) Unilateral facetectomy approach for lateral lumbar disc herniation. *J Neurosurg* 74:754–756
- Gioia G, Mandelli D, Capaccioni B, Randelli F, Tessari L (1999) Surgical treatment of far lateral lumbar disc herniation. Identification of compressed root and discectomy by lateral approach. *Spine (Phila Pa 1976)* 24:1952–1957
- Hodges SD, Humphreys SC, Eck JC, Covington LA (1999) The surgical treatment of far lateral L3–L4 and L4–L5 disc herniations. A modified technique and outcomes analysis of 25 patients. *Spine (Phila Pa 1976)* 24:1243–1246
- Kunogi J, Hasue M (1991) Diagnosis and operative treatment of intraforaminal and extraforaminal nerve root compression. *Spine (Phila Pa 1976)* 16:1312–1320
- MacNab I (1971) Negative disc exploration: an analysis of the cause of nerve root involvement in sixty-eight patients. *J Bone Jt Surg (Am)* 53:891–903
- O'Hara LJ, Marshall RW (1997) Far lateral disc herniation. The key to the intertransverse approach. *J Bone Jt Surg Br* 79:943–947
- Ohnhaus EE, Adler R (1975) Methodological problems in the measurement of pain: a comparison of the verbal rating scale and the visual analogue scale. *Pain* 1:379–384
- Ozveren MF, Bilge T, Barut S, Eras M (2004) Combined approach for far-lateral lumbar disc herniation. *Neurol Med Chir (Tokyo)* 44:118–122
- Porchet F, Chollet-Bornand A, de Tribolet N (1999) Long-term follow up of patients surgically treated by the far-lateral approach for foraminal and extraforaminal lumbar disc herniations. *J Neurosurg* 90(1 Suppl):59–66
- Quaglietta P, Cassitto D, Corriero AS, Corriero G (2005) Paraspinal approach to the far lateral disc herniations: retrospective study on 42 cases. *Acta Neurochir* 92:115–119
- Ryang YM, Rohde I, Ince A, Oertel MF, Gilsbach JM, Rohde V (2005) Lateral transmuscular or combined interlaminar/paraisthmic approach to lateral lumbar disc herniation? A comparative clinical series of 48 patients. *J Neurol Neurosurg Psychiatry* 76:971–976
- Salame K, Lidar Z (2010) Minimally invasive approach to far lateral lumbar disc herniation: technique and clinical results. *Acta Neurochir* 152:663–668
- Sasani M, Ozer AF, Oktenoglu T, Canbulat N, Sarioglu AC (2007) Percutaneous endoscopic discectomy for far lateral lumbar disc herniations: prospective study and outcome of 66 patients. *Minim Invasive Neurosurg* 50:91–97
- Siebner HR, Faulhauer K (1990) Frequency and specific surgical management of far lateral lumbar disc herniations. *Acta Neurochir* 105:124–131
- Silverplats K, Lind B, Zoëga B, Halldin K, Rutberg L, Gellerstedt M, Brisby H (2010) Clinical factors of importance for outcome after lumbar disc herniation surgery: long-term follow-up. *Eur Spine J* 19:1459–1467
- Vogelsang JP, Maier H (2008) Clinical results and surgical technique for the treatment of extreme lateral lumbar disc herniations: the minimally invasive microscopically assisted percutaneous approach. *Zentralbl Neurochir* 69:35–39
- Weiner BK, Dabbah M (2005) Lateral lumbar disc herniations treated with a paraspinal approach: an independent assessment of longer-term outcomes. *J Spinal Disord Tech* 18:519–521