

38 The Full-endoscopic Interlaminar Approach for Lumbar Disc Herniations

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38.1 Terminology

Full-endoscopic interlaminar approach is the term for a newly developed method for full-endoscopic uniportal operation of the lumbar spinal canal and neighboring structures under visual control and continuous fluid flow via a minimally invasive access through the interlaminar window.

38.2 Surgical Principle

Minimally invasive techniques may reduce tissue damage and its sequelae [71, 86, 100]. Endoscopic operations offer advantages which raise these procedures to the standard in many areas. Working with lens optics under fluid enables excellent visual conditions, and bleeding can be reduced. The use of the laser or high-frequency bipolar current is possible in the immediate vicinity of neural structures [22, 81]. Prerequisite is that the technical possibilities of such operations guarantee that the surgical goals will be attained [57].

The most common full-endoscopic uniportal procedure is the *transforaminal* or *extraforaminal* operation with posterolateral access [42, 46, 47, 55, 59, 85, 89, 95, 97, 106]. Retrograde resection of pathologies within the spinal canal is technically demanding and often not possible. Through an extreme lateral approach the posterior annulus and the spinal canal can be reached using the foramen intervertebrale as corridor. This transforaminal approach may be impeded at the caudal levels by the pelvis. Another limitation is the restricted mobility in the spinal canal due to the bony borders of the foramen [43].

The newly developed full-endoscopic uniportal *interlaminar* technique is applicable in transforaminal technically inoperable lumbar pathologies when specific criteria are taken into account. With minimized traumatization, the spinal canal is reached through the interlaminar window, guaranteeing working conditions under excellent visual control like those in conventional techniques, but in a minimally invasive pro-

cedure. The known consecutive problems of open, microscopically or endoscopically assisted techniques can be reduced [71, 86, 100].

38.3 History

Reaching the spinal canal via an interlaminar access using total or partial laminectomy has been described since the early twentieth century [2, 10, 64, 74, 92, 94]. Alternative methods were developed for the operation of intravertebral disc pathologies only 30 years later [38]. Transforaminal mechanical disc decompression has developed through chemonucleolysis [90] since the early 1970s [31, 35, 45, 58, 70]. The corresponding posterolateral approach was first described in the late 1940s as part of vertebral body biopsies [98]. Optical systems have been used since the 1980s [26]. The operative procedure currently consists of a full-endoscopic procedure under continuous fluid flow in a uniportal technique. Clinical results and further technical developments have been published to date in numerous articles [42, 43, 46–48, 55, 59, 61, 85, 89, 95, 97, 106].

In conjunction with the interlaminar approach, a microsurgical procedure was developed in the late 1970s [11, 28, 29, 105]. Since the late 1990s, publications have appeared about endoscopically assisted procedures [9, 16, 67, 72, 86]. But there are no reports on full-endoscopic uniportal techniques for sufficient mechanical decompression of the spinal canal under visual control via interlaminar access.

38.4 Advantages

Conventional open operation procedures will remain as indispensable in the future as they are today. The possible complications and consecutive damage of such procedures are known [1, 5, 13, 17, 27, 32, 33, 37, 41, 49, 50, 52–54, 56, 75, 80, 82, 87, 88, 99]. New techniques must at least guarantee possibilities of attaining the operative goal equal to those of known procedures

[57]. However, it is unthinkable that problems in spinal surgery can be completely avoided.

As a truly minimally invasive procedure, the full-endoscopic uniportal interlaminar operation offers the following possibilities and advantages:

- Sufficient working within the spinal canal and its neighboring structures under excellent visual conditions and short operation times.
- Preservation of epidural lubricating tissue, reduced epidural scarring, and avoidance of a post-discotomy syndrome.
- Minimized resection of bone and ligaments, possible reduction of surgery-induced instabilities.
- Subsequent operations are not made more difficult.
- No surgery-related increase in back pain.
- Reduced traumatization of the surrounding tissues.
- Reduced complication rate, such as dural injury, bleeding, infections, etc.
- Short hospitalization, rapid rehabilitation, high rate of return to earlier level of activity in sports and occupation.
- No increase in morbidity in concurrent illnesses and advanced age.
- High patient acceptance.
- Applicable in transforaminal technically inoperable pathologies.

38.5 Disadvantages

The mobility within the spinal canal is limited by the size of the interlaminar window. At levels cranial to L5/S1, the size frequently hinders access without bone removal. More extensive bony resections are technically more demanding with the currently available instruments since the use of high-speed burrs or bone punches is limited by the size of the access. This is especially true in pronounced spinal canal stenosis and fusions, in which parts of the lamina must be removed to reach the intervertebral space.

Compared to the transforaminal approach, the interlaminar procedure results in a defect in the ligamentum flavum and possibly resection of bony structures, despite its minimal invasiveness. Thus, the full-endoscopic uniportal transforaminal operation can be rated as less traumatic and can offer advantages in appropriate indications, taking the clear limitations into account.

38.6 Indications

The indication for operation corresponds to currently valid standards [3, 63]. The most experience has been

gained in the therapy of disc prolapses and lateral spinal canal stenoses. New instruments are constantly expanding the spectrum of indications. Extensive central spinal canal stenoses have been operated on only for a short time and procedures are still in development. Existing concurrent pathologies, such as instabilities, may have to be co-theraped with other procedures. The following indications are presently clear:

- Sequestered or non-sequestered disc herniations within the spinal canal: in extensive dislocation to the next level, a bilevel procedure may be necessary, in combination with intra- or extraforaminal prolapses, an additional full-endoscopic transforaminal operation may be performed.
- Recurrent disc herniations after conventional or full-endoscopic operations.
- Lateral bony and ligamentary spinal canal stenosis.
- Zygapophyseal joint cysts.
- Intervertebral monosegmental fusions with expandable cages in combination with percutaneous dorsal transpedicular or translaminar stabilization: an interlaminar instead of transforaminal procedure is only used when decompression is necessary within the spinal canal or a transforaminal procedure is technically not possible.

38.7 Contraindications

In addition to general surgical contraindications, the following limitations are given currently for the full-endoscopic interlaminar procedure because of a lack of experience or because of technical limitations:

- Compressive intra- or extraforaminal pathologies: a full-endoscopic trans- or extraforaminal procedure with posterolateral to extreme lateral access is indicated in such cases.
- Extensive central spinal canal stenoses.
- Fusions in instabilities which cannot be reduced by positioning, and in spondylolysis: conventional systems with repositioning possibilities must be used in such cases.
- Multisegmental fusions.
- Pronounced bony shift in the interlaminar window to the cranial levels: due to the required demanding bone resection with currently available instruments, a conventional procedure should be considered in transforaminal technically inoperable pathologies.

38.8 Patient's Informed Consent

As with conventional procedures, patients must be informed about their disease, its possible long-term course and consequences, as well as all known side effects, complications, and therapeutic possibilities, despite the minimal invasiveness and the resultant advantages for the surgical procedure [60]. In addition, it must be emphasized that therapy of a possible complication may require a change of the surgical strategy to an open procedure.

38.9 Surgical Technique

As with all microsurgical techniques, surgery must be planned preoperatively based on imaging findings. The goal is to resect spinal structures as sparingly as possible, depending on the pathology. This applies especially to the selection of access in relation to the size of the interlaminar window and the craniocaudal level of the interlaminar window in relation to the level of the pathology (Figs. 38.1, 38.2a, b).

The full-endoscopic interlaminar operation is usually performed under general anesthesia. This is more comfortable for the patient and the surgeon, enables positioning as required, and also enables extensive working within the spinal canal. The procedure may be performed under local anesthesia only in case of excessive risk for general anesthesia. In such cases, local anesthesia of the route of access and also of the neural structures is necessary. Due to inflammatory processes, epidural anesthesia alone is usually not sufficient, so intrathecal administration of local anesthetic must be

made. In addition, systemic sedation is necessary for immobilization. Due to positioning, this requires costly control of vital parameters, and correction of anesthesiological problems is difficult. Thus, in weighing possible risks, performance of the procedure under local anesthesia is reserved for rare exceptions.



Fig. 38.1. The spinal canal can be reached without bone resection from L5/S1 to L3/4 in appropriate anatomy



Fig. 38.2. **a** There is no limitation by the size of the disc prolapse. **b** The minimal traumatization is visible 2 hours postoperative. The intervertebral space L5/S1 is still filled with lavage fluid

The operation is performed with the patient in a prone position on an X-ray permeable table under orthograde radiological control in two planes. To relieve abdominal and thoracic organs, the patient lies on a hip and thorax roll. The operating table is adjustable to enable a lordotic or kyphotic positioning. Single-shot antibiotics is applied for infection prophylaxis.

Access is first created under anterior-posterior X-ray control. The penetration site in the skin is directed craniocaudal depending on the anatomical and pathological situation and the preoperative planning toward the target spot within the spinal canal. The entry point is chosen close to the midline in order to reach the spinal canal lateral below the zygapophyseal joints with no or as little bone resection as possible. After a puncture incision of 7 mm in length, the dilator is inserted flat to the lateral edge of the interlaminar window. Incision of a thick muscle fascia may facilitate penetration. The subsequent steps are performed under lateral fluoroscopic control. The working sleeve with beveled opening is inserted through the dilator toward medial. After the dilator is removed, the endoscope is inserted and the operation performed under visual control and gravity-operated fluid flow (Fig. 38.3).

First the ligamentum flavum is exposed then incised with the micropunch. The fluid flow causes displacement of the cauda equina from the ligament. If the interlaminar window is not large enough, the bone is first resected with a burr, depending on the finding, without opening the ligamentum flavum. Then the incision in the ligament is increased to maximum of 5 mm to enable entry into the spinal canal. The neural struc-

tures are exposed, preserving the epidural lubricating tissues (Fig. 38.4). The further surgical steps depend on the pathology. Disc herniations, cysts of the zygapophyseal joints and lateral spinal canal decompression can usually be handled without further access-related resections. In extensive sequester dislocations, preoperative planning may show that resection of parts of the lamina might be necessary prior to opening the ligamentum flavum. Whereas medial excision of the superior articular process is usually sufficient in pure recessus stenosis, more advanced stenosis may require more extensive bone resections.

The operating sheath with beveled opening serves as a second instrument and as a nerve hook. By rotating the opening, the neural structures can be held aside and protected. Using optics with the joystick principle enables mobility within the spinal canal. Various stiff or flexible instruments of different sizes, as well as shavers and grinders are available for the individual working steps (Fig. 38.5). High-frequency bipolar current is used for preparation and to stop bleeding. The use of the holmium:YAG laser for tissue ablation can be helpful only in exceptional cases.

At the conclusion of the operation, the instruments are removed and the puncture incision sutured. No drainage is necessary.

In revision operations, the dilator is inserted further lateral to contact with the bony parts of the zygapophyseal joint in order to avoid injury to the neural structures due to an already-existing defect in the ligamentum flavum. Preparation is made from this safe zone under visual control toward medial to the end of the



Fig. 38.3. Full-endoscopic uniportal operation with interlaminar access

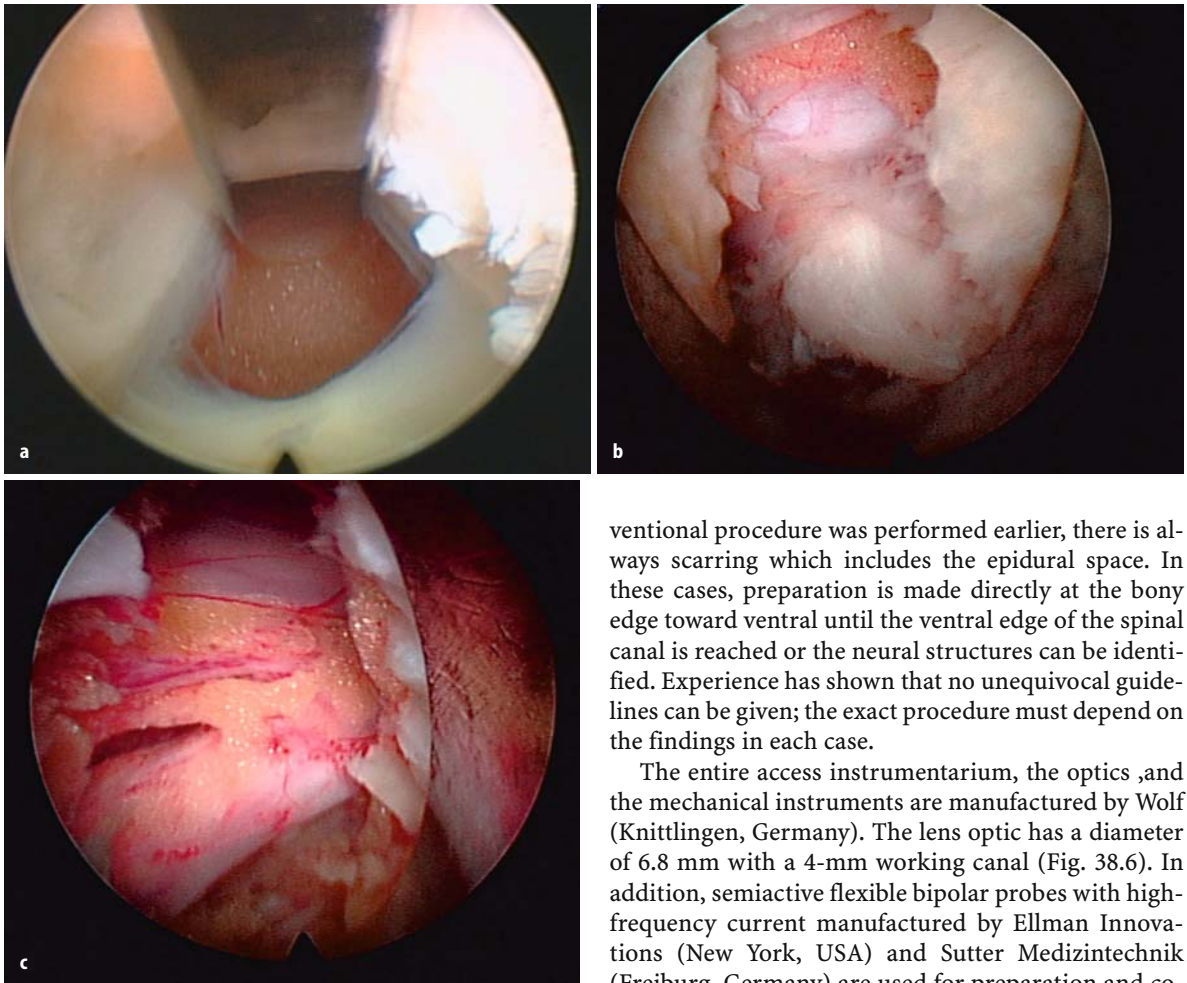


Fig. 38.4. **a** Incision of the ligamentum flavum. **b** Opened ligamentum flavum, traversing nerve pushed dorsal due to the sequestered material. **c** Cauda equina, traversing nerve, and axilla after decompression



Fig. 38.5. Instruments and burr with a maximum diameter of 4 mm

bone and start of the spinal canal. When a prior full-endoscopic operation was performed, the former access in the ligamentum flavum is sought and reopened. There is no severe difficulty due to scarring. If a con-

ventional procedure was performed earlier, there is always scarring which includes the epidural space. In these cases, preparation is made directly at the bony edge toward ventral until the ventral edge of the spinal canal is reached or the neural structures can be identified. Experience has shown that no unequivocal guidelines can be given; the exact procedure must depend on the findings in each case.

The entire access instrumentarium, the optics, and the mechanical instruments are manufactured by Wolf (Knittlingen, Germany). The lens optic has a diameter of 6.8 mm with a 4-mm working canal (Fig. 38.6). In addition, semiactive flexible bipolar probes with high-frequency current manufactured by Ellman Innovations (New York, USA) and Sutter Medizintechnik (Freiburg, Germany) are used for preparation and coagulation.

38.10 Postoperative Care and Complications

The length of stay in hospital depends on the operative measures. Nucleotomies alone or simple decompressions require short stays or, if the patient can be adequately cared for at home, can be performed on an outpatient basis. Mobilization is immediate, that is as soon as the patient has recovered from general anesthesia. Operation-related pain medication is not necessary. With the exception of patients with motor deficits, no rehabilitative measures are necessary. The patient may perform isometric and coordination exercises on his own after a training phase, and a passive lumbar brace is prescribed for daytime use for about 6 weeks. The loading level can be increased depending on pathology and subjective well-being. Return to work and sports is possible under the same conditions after wound healing. Limitations are imposed only in that there should be no increase in pain under the activity. In the case of

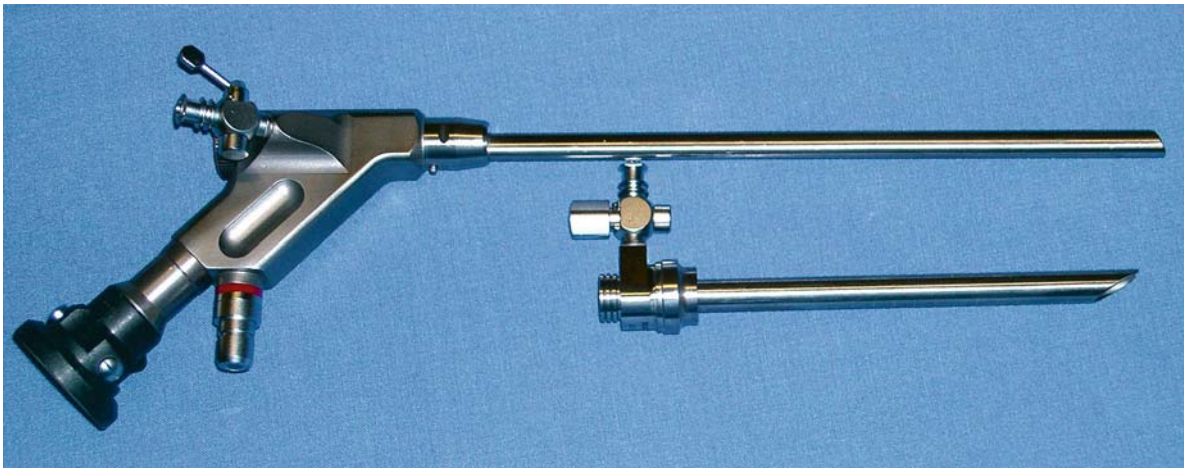


Fig. 38.6. Endoscope for uniportal procedure and oblique operation cannula

more extensive spinal canal dilatations or fusions, possibly with dorsal stabilization, the postoperative treatment scheme is usually more restrictive and depends individually on the measures performed.

Possible complications are known to be associated with microsurgical procedures and are reported in numerous publications [12, 60, 76–78, 93, 100, 102, 104]. A minimally invasive procedure reduces the rate of complications [71, 86, 100]. In more than 1,500 full-endoscopic interlaminar operations performed, there have been no operation-related complications. Statistically, however, these can be expected in future, even if only to a relatively low degree. Results today after decompressions especially show no symptomatically epidural scarring, no post-discotomy syndrome, and no difficulties in subsequent operations. As known today, operation-induced instabilities are minimized when bony resection of stabilizing structures is restricted to a minimum [1, 32, 37, 41, 49, 52, 53, 88].

38.11 Results

Results of full-endoscopic uniportal operations have been published only for posterolateral access in a transforaminal technique [42, 43, 45, 46, 55, 59, 85, 89, 97, 106]. Since its development in 2001, more than 1,500 patients have undergone interlaminar operation. As an excerpt, prospective 1-year results of 204 patients with sequestered lumbar disc herniation are presented.

Two surgeons operated on 263 patients. Thirty-one non-German-speaking patients were excluded because of validation problems. The study population thus consisted of 232 patients, 128 women and 104 men. The age range was from 17 to 76 years, mean 41 years. The duration of pain ranged from 1 day to 16 months, mean 87 days. Fourteen patients had undergone prior con-

ventional surgery at the same level, and 19 at a different level. Conservative treatment had been used in 182 patients for a mean of 10 weeks, and 50 had undergone acute operation. The indication was defined according to current standards on the basis of radicular symptoms and existing neurological deficits [3, 63]. One hundred and fifty-seven interventions were made at level L5/S1, 68 at L4/5, 5 at L3/4, and 2 at L2/3.

In addition to psychometric tests in pain therapy, the following validated measuring instruments were used: visual analog scale (VAS) for back and leg pain (always for the period of 1 week before re-examination), German version North American Spine Society Instrumentarium (NASS) [14, 73], and Oswestry Low Back Pain Disability Questionnaire [23]. (This score has not been unequivocally validated for German language use, but it was used in a translated version since it is broadly used internationally.) With respect to general criteria, the focus was on the following parameters: sufficient decompression, complications, operation time, bleeding, scarring, postoperative pain, postoperative therapy, pain reduction, reduction of neurological deficits, rehabilitation time, work disability, occupational capacity, athletic capability, recurrence, revisions, and subjective satisfaction.

Two hundred and four (88%) patients were included in the complete postoperative examination program. There was no dependence on gender, age, height, weight, educational level, insurance status, status on the job market, or concurrent diseases. The mean operation time was 29 minutes. There was no measurable blood loss. No patient experienced operation-related complications. Mobilization was possible without exception a few hours after operation.

Seventy-six patients without prior operation presented intraoperative with extensive epidural adhesions. In 16 patients (8%), contrary to the MRT findings, only hard tissue histological annulus ligament or

cartilaginous nucleus tissue were found intraoperative. In these cases, there was a significant relationship to existing back pain and duration of complaints of more than 6 months. Of these patients, 3 were reoperated using fusion.

Three patients (1.6%) suffered recurrent disc prolapse during the first 6 months. All revisions were performed using the same technique. Of these, another recurrence was suffered in one case, which was also endoscopically operated. The recurrent prolapses consisted histologically of more than 75% of endplate components.

The results of the measuring instruments of 198 non-recurrent patients showed a constant improvement with the exception of the isolated backpain rating. No further leg pain was reported in 162 patients (82%), 26 (13%) had only occasional or greatly reduced leg pain, and 10 (5%) reported no essential improvement. The latter belonged without exception to the group of patients with prior operation at the same level or intraoperatively diagnosed hard tissue and epidural adhesions. There was no significant operation-related deterioration of existing symptoms. No post-discotomy syndrome occurred. Significant dependencies were found between poorer results and longer history of back pain. Of all 204 patients, 186 (91%) reported subjective satisfaction and would undergo the procedure again. This applies as well to 192 (97%) of the 198 non-recurrent patients.

The 156 patients who were neither unemployed nor retired returned to work or to sports activities; 9 were unable to do so because of persistent pareses. The mean postoperative work disability was 11 days.

An MRT was recorded 31 times postoperative after a period of 3 months. Epidural scarring was not diagnosed either at that time or during revision procedures. The closure of the defect in the ligamentum flavum proceeded without involving the epidural space, and the fatty tissue was preserved. The primary operation did not make the revision procedure more difficult.

There were no differences in results within the various levels. An access-related bony resection was necessary above the level L5/S1 in 24 cases. This affected exclusively dorsal segments of the inferior articular process and the inferior part of the cranial lamina. The use of bipolar high-frequency probes was found to be necessary in all cases for preparation and to stop bleeding. Measurement of the lavage inflow and outflow showed a maximum of 100 cc of fluid remaining intracorporally.

38.12 Critical Evaluations

The goal of operations for lumbar disc herniations is sufficient decompression with minimization of sur-

gery-induced traumatization and its sequelae. The present results show that the full-endoscopic uniportal interlaminar operation is able to achieve these goals for the indications described.

The constant reduction of leg pain, as one of the main therapeutic criteria, is to be rated as a causal success of sufficient decompression under visual control. The results of microscope-assisted operations, which are between 75% and 100%, are attained [4, 21, 25, 34, 53, 62, 69, 103]. Operation times, tissue traumatization, and complications such as dural injury, nerve damage, bleeding, or infections are minimized [12, 76–78, 93, 100, 102, 104]. The remaining levels in NASS pain and Oswestry result from the lack of reduction in back pain, which is to be expected in the present indications [4, 20, 21, 53, 78]. In accordance with the published advantages of a minimally invasive intervertebral and epidural procedure [7, 24, 65, 79], there is no progredience of existing symptoms. The possibility of reducing or dispensing with osseous and ligamentary resection and the minimally traumatic evacuation of the intervertebral space serves in today's understanding to avoid operation-induced instabilities [19, 24, 30, 39, 40, 44, 53, 65, 66, 68, 79, 107]. No operation-related rehabilitative measures are necessary. There is a comparably high return to the preoperative level of occupational and athletic activity [18]. Criteria such as gender, age, height, weight, educational status, insurance status, or status in the job market had no influence. There was no increased morbidity with secondary factors [12, 76, 93].

The recurrence rate of 1.6% after 6 months lies within the range for conventional techniques [8, 36, 91, 101]. Revisions can be made using the same technique. The negative effects of complete resection of a degenerated nucleus, of which the biomechanical value is questionable, have not yet been completely elucidated [54, 56, 65, 108]. Minimization of the annulus defect may have greater protective influence than preservation of the nucleus [108]. Since evacuation at least of the dorsal area appears to reduce the frequency of recurrences, the authors resect the nucleus material with minimal trauma using new flexible instruments depending on the configuration of the annulus defect. Complete avoidance of recurrences cannot be expected since more than 75% consists of endplate material.

No case of post-discotomy syndrome occurred during the entire postoperative observation period. Epidural scars were not found either in MRT examinations nor revision surgeries were more difficult. Such scars are to be expected in conventional techniques and may lead to clinical symptoms in up to more than 10% [5, 27, 54, 56, 82, 87]. Subsequent endoscopic or conventional procedures can be performed without severe difficulty and show none of the prolongation of operation time described for other procedures [96]. In addition, the epidural lubrication tissue is preserved. This agrees

with descriptions of better results and reduced traumatization of the ligamentum flavum [6, 15].

The general relationship between longer history and poorer outcome is currently not rated as a decisive indication for early operation in light of the minimally invasive procedure. Patients with poor results in the present study presented without exception with additional secondary factors in the sense of degenerative fibroses which could not be clearly diagnosed by imaging [82, 83] such as are known in endoscopic operations in the absence of disc herniation [51, 83, 84].

Complete and safe resection of disc fragments and other pathologies within the spinal canal must be performed under visual control. In a full-endoscopic uniportal procedure, the transforaminal operation can be rated less traumatic than the interlaminar operation due to the reduced osseous and ligamentary resections. At the same time, it does have clear technical limitations. Thus, in transforaminal technically inoperable pathologies, the interlaminar approach is indicated, taking the appropriate criteria into consideration. In general, anatomy and pathology dictate the surgical approach. Newly developed optics with a 4-mm working canal and corresponding actively flexible instruments enable resections of hard tissues. However, at present extensive bone resections, for example in central stenosis, are demanding.

In summary, the present study results show possibilities of sufficient decompression which are equal to those of conventional procedures, a minimum which must be attained by a new procedure [57]. At the same time, all of the advantages of a truly minimally invasive procedure with low traumatization and rapid operation time are given. Complications or increased morbidity of elderly patients are slight. Brief hospitalization, rapid rehabilitation, and high patient acceptance are observed. There are still problems with extensive bone resections. The authors consider the presented technique to be a sufficient and safe alternative or supplementation to open, microscopically or endoscopically assisted procedures. With the possibility of selecting an interlaminar or transforaminal posterolateral to extreme lateral access, sequestered disc herniations outside and inside the spinal canal can now be sufficiently operated in a full-endoscopic uniportal approach, taking the criteria into account. The same applies to cysts of the zygapophyseal joints and lateral spinal canal stenoses. In fusions, the intervertebral procedure is possible, taking the indication criteria into account. Possible advantages with respect to destabilization and scarring when the procedure is extended to more serious pathologies with the consecutive necessity of more extensive ligamentary and osseous resections must be demonstrated by future events.

Overall, a development potential is seen from a technical point of view which may lead to expanded indica-

tions. However, complete avoidance of the known problems in spinal surgery is hardly imaginable even with new techniques. In addition, in the future as now, open procedures will remain indispensable.

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