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Classification and management of early complications in open lumbar microdiscectomy

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Abstract Complications and side effects in any kind of surgery, especially in spine surgery, should be evaluated to prevent those problems in the future. Since retrospective studies are of minor value and randomized controlled studies for complications are impossible to perform because of ethical and legal reasons, so-called “expert opinion” has to take their place in evidence-based medicine. On the basis of an analysis of the results of three spine centers together with the opinions of experienced spine surgeons, the authors have drawn up a classification of complications in open lumbar disc surgery and recommendations on how to manage common complications such as excessive bleeding, dural opening, nerve root lesions and recurrent disc herniation. The man-

agement of intraoperative complications should have the same training in microdiscectomy instructional courses as the operation itself.

Keywords Microdiscectomy · Complications of spine surgery · Dural tears

Introduction

Though open lumbar disc surgery is still the most frequent and the most important intervention in spine, in the last two decades more papers about other procedures such as percutaneous intradiscal therapy or instrumented fusion have been published. One reason may be that there have been no significant developments concerning this operation in the last years. Another factor may be that industry has little interest in open disc surgery because there is nothing to inject or to implant. Once you have the microscope and instruments you are equipped for a life time.

Only a few publications consider the complications and side effects of open disc surgery; these topics are mainly to be found in books by experienced spine surgeons [11,

13]. The last multicenter studies of any great value in this field took place many years ago [14, 15, 20]. Studies about complications in lumbar spine surgery are very important, because poor patient selection and intraoperative complications mostly end up in failed back surgery syndrome.

Open lumbar disc surgery is known not to be life threatening, but is nevertheless risky. In our European Spine Society questionnaire [8] to evaluate a risk and value score for different diagnostic and therapeutic procedures in spine, open discectomy had the highest effectivity rate but a negative overall risk value score because of complications and poor results. Our studies in the past years considered different factors that influenced the outcome of open lumbar disc surgery with reference to the predictors for failed back surgery syndrome [4, 8].

Experiences of the senior author and personal information from well-recommended members of the International Society for the Lumbar Spine (Dyk, neurosurgeon, Los Angeles; Findlay, neurosurgeon, Liverpool; Wiltse, orthopaedic surgeon, Long Beach, US; Yoshizawa, orthopaedic surgeon, Tokyo) lead to recommendations in this overview that also feature in the Spine Society of Europe microdiscectomy instructional course taught at the Universities of Bochum and Düsseldorf.

Classification

Complications of open lumbar disc surgery are divided into intraoperative, immediate postoperative and late postoperative, according to the time when they become apparent rather than the time they happen. It is better for the management of complications to have guidelines for symptoms and side effects at the time they start to give symptoms.

With regard to the intraoperative complications, there is a long list of all that can happen during micro disc surgery. By definition, intraoperative complications are recognized immediately by the surgeon and should be registered in the protocol. Statistical analyses can be performed by evaluating these protocols. Unfortunately, reports are not always complete, so the real frequency remains uncertain. Many of these problems can be avoided by an exact preoperative planning that takes into consideration the predictors of complications [12, 18]. Some of the intraoperative complications are common and belong to the routine of open lumbar disc surgery, such as bleeding from epidural veins and durotomy. These can be managed quite easily. Other complications such as anterior vessel and visceral injury are severe; however, they are fortunately extremely rare (Table 1).

Immediate postoperative complications can also be either general, which can happen after any kind of surgery, like vomiting, thrombosis and circulatory problems, or specific to spine surgery.

Some of the specific spine complications are established during the operation, but go unrecognized by the surgeon and become symptomatic in the following days, such as missed pathology, complications secondary to positioning, abdominal symptoms and bladder disturbances. They are mostly well documented in the patients' reports

Table 1 Intraoperative complications of lumbar disc surgery

Wrong level
Missed pathology
Other pathology
Bleeding
Durotomy
Nerve root lesion
Anterior vessel and visceral injury

Table 2 Immediate postoperative complications in lumbar disc surgery

Postoperative leg pain
Residual symptoms
New symptoms
Lesions from intraoperative positioning
Bladder disturbances
Cauda syndrome
Abdominal symptoms
Thromboembolism
Infection
Epidural hematoma

Table 3 Late postoperative complications after lumbar disc surgery

Thromboembolism
Recurrent disc herniation
Spondylodiscitis
Failed back surgery syndrome (postdiscectomy syndrome)
Meningocele due to unrecognized dural leak
Macroinstability

Table 4 Classification of complications in open lumbar disc surgery

Preoperative
Intraoperative
Immediate postoperative
Late postoperative
General/Specific
Severe/Not severe
Common/Rare
Evaluation complete/ Evaluation incomplete

during the hospital stay by several doctors and nurses, and can be evaluated exactly (Table 2).

Late postoperative complications after lumbar disc surgery are those that become apparent after the patient has left the hospital. Besides general complications such as thromboembolism, they include recurrent disc herniation, a slow-developing spondylodiscitis and failed back surgery syndrome due to peridural fibrosis and instability (Table 3).

Late complications can only be evaluated by questionnaires or follow-up studies with patient examination. Not all patients consult their surgeon when these complications arise. Follow-up studies are also generally incomplete, as some patients may not be willing to fill in the questionnaires or may have moved away.

Table 4 gives a summary of the classification of complications in open lumbar disc surgery.

Intraoperative complications

Missed preoperative checklist

The surgeon performing a lumbar disc operation should examine the patient 1 day before surgery to note the re-

cent symptomatology. Symptoms can change over a short period of time because of fragment migration or shrinking process.

Even though the indication is right and a very experienced surgeon is involved, complications can still arise when computed tomography (CT) or magnetic resonance imaging (MRI) are not available prior to surgery.

Technical problems with the X-ray for the needle landmark to identify the lumbar segments precisely are possible. The difference between the last lumbar segment visualized by MRI and the same one visualized by X-ray in the lateral view has to be considered. Sometimes a lumbosacral segment can be seen on an MR image but not on a radiograph.

General anesthesia should only start when all the imaging is complete, including an X-ray with the needle landmark, and when the microscope has been checked up before draping it.

Wrong level exploration

Exact preoperative planning is one of the main prerequisites for avoiding a specific complication of microsurgery: exploration of the wrong level. For McCulloch and Young [11] it is the most important one. In our comparative study [4], wrong level exploration at the beginning of surgery happened in the group of very experienced surgeons in 1.2% of cases and in the group of less experienced surgeons in 3.3% of cases ($P < 0.01$).

It happened more often for both groups in L4/5 and higher segments than in L5/S1. In all cases the correct segment had been identified intraoperatively by X-ray.

Missed pathology

Missed pathology means that pathology which caused the clinical symptoms and should have been removed, mostly disc material or bony entrapment, is left in the spinal canal or foramen when the wound is closed. This can happen when wrong level exploration is not recognized. The patient wakes up and has the same or even greater pain than before.

Other pathology

Other pathology means the surgeon finds pathologic structures that are different to those expected, but which could have caused the clinical symptoms. Only thickened epidural veins and ligamentum flavum cannot be held responsible for the clinical symptoms in place of the expected disc herniation. In these cases it is necessary to perform intraoperative X-ray or (and) myelogram to avoid missed pathology.

Bleeding epidural hematoma

Epidural hematoma causing symptomatic neurologic compression or cauda equina syndrome is one of the most feared complications of spine surgery [3]. During a posterior approach, the lumbar spinal canal arterial bleeding from the back muscles and epidural venous bleeding are the most important ones. Intraoperative bleeding can be minimized by positioning the patient prone with hanging abdomen.

Artery bleeding

Artery bleedings in the back muscles should be checked and coagulated carefully, because they are able to pump up the wound postoperatively when it is closed, and compress the dural sac leading to cauda syndrome.

Epidural veins

Epidural vein bleedings do not cause the compression of the dural sac with consequential cauda equina syndrome. This opinion of experienced spine surgeons ([3, 11], and Findlay 1998, personal communication) is important to bear in mind in situations where it is almost impossible to leave a “dry” spinal canal at the end of an operation, because of inaccessible epidural venous bleeding which lies anterior to the nerve root. Epidural vein bleeding often stops when the disc fragment is removed and after wound closure. We prefer to tamponade as long as possible before using bipolar cautery. Excessive cautery of epidural veins inhibits the nutrition of the nerve roots and is the cause of epidural fibrosis. On the other hand, epidural hematoma, even if it does not compress the dural sac, can also cause epidural fibrosis. The main reason to prevent and stop bleeding from epidural veins is their obscuring of the visual field. Because of the limited approach in microdiscectomy, even a small amount of bleeding appears as a major hemorrhage under the microscope. Especially for less experienced microsurgeons, it is hard to remove all the protruded disc material under these circumstances. Therefore, the following precautions have to be made to prevent intraoperative bleeding:

- Position the patient with hanging abdomen.
- Avoid exploring the posterior surface of the vertebra if it is not necessary.
- Push aside epidural veins with the retractor before entering the disc space.
- Cauterize the veins if they lie unmovable in your area of interest.

If epidural vein bleeding occurs, it is better to remove as much as possible from the protruded disc material before taking care of the bleeding. The bleeding during this ma-

never could be managed by continuous suction and the use of cottonoid tamponade. After removal of the disc prolapse it is easier to expose the bleeding vein and cauterize it, if necessary, with an appropriate distance to the neural structures in the spinal canal.

For continuous bleeding from cancellous bone after bone removal we take a small amount of bone wax.

In our series, excessive bleeding happened in the group of experienced surgeons in 7.1% of cases, and in the group of very experienced surgeons in 3.5% of cases. In all cases excessive epidural vein bleeding was not the cause of further intraoperative or immediate postoperative complications [4].

Drainage or not?

The routine use of wound drainage after lumbar microdiscectomy is a matter of debate. Some authors use it routinely [3] and some occasionally ([7, 11] and Dyk 1998 and Findlay 1998, personal communications). We performed a prospective randomized study [7] and found out that it makes no difference for early results and outcome after 1 year whether wound drainage is used in lumbar microdiscectomy or not. So we don't use postoperative wound drainage in microdiscectomy routinely. Just to be certain, we take a wound drainage in case of excessive epidural bleeding, bone removal and in any case of widening the approach.

Dural opening

Injuries to the dura with consequent cerebrospinal fluid (CSF) loss can happen in all kinds of spine surgery. Clear fluid in the wound should not automatically mean a dural tear. It could also come from a puncture hole after previous myelography or inadvertent dura puncture from an epidural injection days before surgery. Other than CSF, clear fluid could be synovial fluid from vertebral joints (with a yellowish tinge) [11] or from a wet tamponade.

Unfortunately, the clear fluid usually does mean CSF from an inadvertent durotomy by surgical instruments. Most common is opening of the dura by incision of the ligamentum flavum. This can happen when the ligamentum flavum is very thin, which occurs in lumbosacral anomalies [11], or when a big disc herniation pushes the dura sac posteriorly, right under the ligamentum flavum. Therefore, we prefer a two-step flavotomy with a special semisharp dissector.

Under special conditions dural opening is necessary to deal with intradural pathology, which is rare in lumbar disc surgery [11].

When a CSF leak with continuous flow is recognized, localization and dimensions of the damage have to be registered: Is it medial or lateral, caused by incision or punch, are nerve roots involved, is there a nerve rootlet hernia-

tion? When the hole is localized, it is better to leave this area and take another approach to the pathology in order not to widen the hole. When the disc herniation is removed there is more space and less tension on the dura for a suture repair. Head down-back up position also reduces dural tension. Tears with a length of more than 3 mm should be closed with 6–0 sutures. The patient should receive antibiotics and be kept in bed for 3 days. The complications of dural tears are headache due to CSF loss, CSF fistula and postoperative pseudomeningocele, which can be seen on MRI. Our own experience with a follow-up study comparing patients who had intraoperative dural tears with the control group showed better results in the control group [4]. With a two-step blunt perforation of the ligamentum flavum, appropriate instrumentation and good visualization of the lateral dura and nerve root border, it should be possible to reduce the number and extent of dural tears in lumbar microdiscectomy to a minimum.

In conclusion, all dural openings are a matter of experience. They happened in the group of less experienced surgeons in 7.2% of cases, and with very experienced surgeons in 0.8% ($P < 0.001$) [4].

Nerve root lesion

The incidence of nerve root lesions after lumbar spine surgery has been estimated at 0.2% [3]. Such injury may be suspected postoperatively by the presence of new or increased neurological deficits. Iatrogenic intraoperative nerve root injuries are classified by the site where they happen proximal to the foramen or extraforaminal, and the way in which the injury occurs: open, by sharp instrumentation, or closed, by excessive traction, compression or by heat from electrocautery. Poor visibility, perineural adhesions and congenital neural anomalies such as conjoined roots are the most common causes for the damage to the nerve roots. Therefore, it is absolutely necessary to define the lateral root and dural sac border before removing any material from the spinal canal. Even when the neural elements are clearly under the nerve root retractor, the tissue in the anterior epidural space should be identified by the 2-mm dissector.

A lesion proximal to the foramen in the paramedial zone of the spinal canal is associated with the appearance of more or less cerebrospinal fluid. Rootlets may herniate. After reduction of the rootlets, the dura must be repaired. Small defects may be covered by a free fat graft, especially when a suture would strangle the nerve root. The most vulnerable area for an open nerve root lesion is the axilla of the exiting nerve root. Thus, maneuvers to remove intradiscal fragments should not take place medial to the nerve root in the axilla. Therefore, one of the principles in the microdiscectomy instructional course is: stay lateral to the nerve root, as best as you can.

Anterior vessel injury, visceral injuries

When the rongeur penetrates the anterior anulus fibrosus it comes into contact with major vessels which lie immediately in front of the lower lumbar discs. Grasping maneuvers in order to clean out the disc material rupture the vessels. The most frequent lesion is an isolated injury of the left common iliac artery [13] caused by maneuvers in the L4/5 disc. The overall complication rate for anterior vessel injury is 0.045% [20]. Only 50% are immediately apparent, with a dramatic unexplained fall in blood pressure and sometimes excessive hemorrhage out of the disc. In these cases disc surgery has to be interrupted immediately by wound closure to turn the patient over for a laparotomy and repair of the injured vessel.

In 50% of the patients, the symptoms of anterior vessel injury and other abdominal injuries are recognized later in the recovery room with unsustainable extreme low blood pressure and painful abdominal swelling. In these cases as well, laparotomy has to be performed immediately. Even with a prompt reaction, the mortality of this complication is around 50% [11].

Prevention of this major complication is possible if intradiscal maneuvers are only allowed with rongeurs, which cannot be inserted deeper than 25 mm correlated to the anterior posterior disc diameter of 35–40 mm on average.

Immediate postoperative complications

Postoperative leg pain and neurological deficits

Most common and not really considered a complication in most cases is persistent or residual leg pain after nerve root decompression surgery of the lumbar spine. Possible causes for postoperative leg pain are listed in Table 5. If you are sure you have operated the right level with satisfying pathology and if neurological symptoms are not severe or progressive you can wait: give analgesics and antiphlogistics such as diclofenac and reassure the patient by saying: “The herniated disc is out the nerve root still hurts” (Findlay 1998, personal communication); or: “It’s like a fish bone you swallowed, even if it is out you still have the feeling”.

However, it is important to keep an eye on the patient, as the possibility of a leftover disc fragment or a recurrent herniation still remains. Indications for a closer postoperative neurological examination and MRI control are:

- Severe leg pain lasting more than 2–3 days
- Progressing neurological deficits
- Any kind of cauda equina symptoms

Residual symptoms

When a nerve root has been compromised for a long time by a disc herniation or an osteophyte, it will not be symp-

Table 5 Causes of postoperative leg pain

Residual symptoms
Intraoperative nerve root lesion
Fragment left, foreign body retention
Early recurrent herniation
Lesions secondary to positioning

tomless immediately after decompression. The factors that are responsible for more or less residual symptoms are not yet known. Causes might be duration of compression, concomitant diseases such as diabetes, intraoperative traumatization, extent of the hematoma, postoperative pain medication and individual pain sensitivity. We carried out double-blind studies to influence postoperative leg pain by intraoperative local application of anesthetics and morphine on the nerve root before starting with the manipulation with instruments, in order to eliminate the so-called memory pain. So far, we can say that local morphine is not able to influence leg pain in the immediate postoperative period.

Intraoperative nerve root lesion

Postoperatively, nerve root lesions during or after surgery are recognized by new or increased neurological deficits as soon as the patient wakes up. The severity of anatomical lesions does not always correlate to the postoperative findings. Some patients only have some local numbness without pain or motor deficits after an open nerve root lesion, others complain about severe leg pain or drop foot after intraoperative traction on the L5 or (and) L4 root.

Missed pathology, foreign bodies

Besides wrong level exposure missed pathology at the right level is the other major criticism of lumbar micro disc surgery. Even if the correct level is explored and the disc prolapse has been removed, further discal fragments can be left behind or bony stenosis may not be decompressed. The patient wakes up and has the same amount of pain, which does not regress in the following days. Pain might even be worse, because of the additional operative trauma and postoperative hematoma. Control MRI will detect the missed fragment or remaining foreign bodies as the worst case.

Early recurrent disc herniation

Immediate postoperative leg pain and neurological symptoms with the same or increased intensity as before surgery can be caused by missed pathology or by an early recurrent disc herniation, which may happen when patients

are moved from the operation table or when they cough while being extubated.

Usually symptoms from a new disc prolapse occur after a painfree interval, as early recurrent disc herniation in the first days after surgery when the patient stands up and starts with axial spine loading. In our series we had 0.2% recurrent disc herniations in the 1st week after surgery [7]. As soon as the new herniation is verified by control MRI, revision surgery in the same segment is necessary. Recurrent disc herniation cannot be avoided by extensive disc curettage ([3, 7, 11, 13] and Yoshizawa 1998, personal communication). It is sufficient to extract further mobile disc material just behind the hole in the anulus, which could develop into a recurrent herniation. Another measure for prevention of early recurrent disc herniation is postoperative back school and a flexion brace (T-Flex, Tigges) for 3 months until the fibrous closure of the hole in the anulus is strong enough to resist further disc fragment migration [7].

Lesions from intraoperative positioning

All variations of kneeling position that are used for lumbar disc surgery can provoke lesions on the skin and neurologic structures by prolonged traction or punctual compression. Brachial plexus stretch and palsies of the radial and ulnar nerve can develop by the hyperabduction of the arm. We observed two cases of slight plexus disturbances in our series, which both disappeared in the following days [4]. Severe lesions from positioning, like myelopathy by hyperextension of the neck or visual disturbances [10, 11, 21] by failure of eye protection during surgery and prone positioning are very rare, and should be avoided by proper head position. Fortunately, we did not observe these complications.

Postoperative cauda equina syndrome (CES)

There is a broad range of possible cauda symptoms from slight bladder disturbances to the fully developed cauda equina syndrome with:

- perineal anesthesia
- decrease of sphincter tone (bladder, bowel)
- bilateral progressive motor weakness

The absence of any of these clinical features does not rule out a cauda equina syndrome. Injury to the cauda equina can occur at surgery from direct damage or postoperatively by hematoma. We never saw a cauda equina syndrome by a dislocated fat graft, though we had a large series in our prospective randomized study examining free fat graft versus non-fat graft [4].

Even where there is an improvement of the preoperative leg pain, any of the cauda symptoms should lead to an

immediate MRI and a closer neurological examination. Immediate surgery to decompress the cauda is necessary, though a recent study [1] showed that there is no statistically significant difference between patients who had decompressive surgery in the first 20 h after the onset of cauda equina syndrome and those with surgery 24–48 h after onset.

Abdominal symptoms

Any kind of surgery can be followed by abdominal symptoms. After the posterior approach for lumbar disc surgery, the surgeon has to pay special attention to the abdomen because there might have been an anterior perforation of the anulus by the instruments during surgery, with delayed symptoms. An incomplete damage to a vessel wall can lead to an arterio-venous fistula, most commonly between the right common iliac and the inferior vena cava [11]. These patients have abdominal symptoms combined with limb swelling, shortness of breath and heart attacks. Injuries of the viscera become symptomatic in the first days after surgery by increasing abdominal pain combined with fever and spasm of the abdominal muscles. Immediate abdominal surgery is necessary.

Thromboembolic symptoms

During spine surgery in the kneeling position, patients have a risk of thromboembolic complications. The rate of the embolic complications in the literature ranges from 0.1 to 1% [10, 14, 19]. The rate of thrombosis of the lower limb must be much higher, and can only be estimated. Thrombosis prophylaxis by early mobilization, and the use antithrombotic stockings must be considered. Additional low-dose heparine application remains a matter of debate [11, 13] because of possible bleedings into the spinal canal. We recommend perioperative low-dose heparine prophylaxis.

Infection spondylodiscitis

Infections in lumbar disc surgery are classified into superficial and deep wound infections. Superficial infections are more or less registered in the perioperative hospital report. The superficial infection rate in lumbar disc surgery is the same as in any other surgery, at 2–3% [13, 14, 17, 19].

Deep wound infections may occur after lumbar disc surgery such as an epidural abscess; however, a postoperative disc space infection (discitis), which mostly extends to a spondylodiscitis, is more frequent. Symptoms arise in the first days after surgery, with fever, severe low back pain and typical blood analyses. A spondylodiscitis can

also become symptomatic after several weeks due to delayed local infection. A hematogenous transmission of bacteria from another part of the body into the wound area can be suspected in these cases. Predictors for infections are concomitant diseases such as diabetes and steroid medication. The incidence of disc space infection ranges from 0.13 to 0.9% in the literature [4, 5, 6, 11, 13, 15, 16, 17]. Most authors recommend infection prophylaxis with antibiotics.

It has been claimed that micro disc surgery has a higher infection rate than standard disc surgery because of the manipulations with the microscope over the top of the open wound. However, recent publications on micro disc surgery [2, 4, 6, 11] and our own experience show that the deep wound infection rate in micro disc surgery is not high.

Besides the typical clinical infection symptoms, which can be masked by postoperative wound healing disturbances, early diagnosis of disc space infection is possible by MRI. Plain radiographs do not show an abnormality for approximately 4–6 weeks after surgery [11, 13].

The treatment of postoperative disc space infection includes systemic antibiotics and, in early stages, a percutaneous debridement of the intervertebral disc space with the instrumentation of percutaneous discectomy [5].

After a treatment, the outcome of postoperative spondylodiscitis is mostly good. More than 50% of the patients progress to disc space obliteration and interbody fusion [11].

Discussion

It is impossible to avoid any complications at all in any kind of surgery, especially in lumbar microdiscectomy. Limited approach and high technology are most sensitive to complications, which always occur with a certain frequency. According to McCulloch and Young [11], the two major criticisms of micro disc surgery are wrong level exploration and missed pathology. If wrong level exposure is not recognized, pathology will be left behind. The risk

Table 6 Procedures to avoid complications in lumbar micro disc surgery

Proper patient selection
Surgeon's training
Preoperative planning
Systematic four-step approach
Infection prophylaxis
Postoperative care

for complications of lumbar micro disc surgery can be minimized if certain requisites are considered and by meticulous attention to preoperative, intraoperative and postoperative detail [3, 12, 18], the main points of which are summarized in Table 6. During the learning curve, it is helpful for a spine surgeon to have advice from experienced spine surgeons, taken from the literature and from personal information, as is provided in this article, about how to avoid intraoperative complications and how to manage them when they happen.

The outcome of lumbar disc surgery depends greatly on proper patient selection [3, 11, 13, 18, 19]. In our study, experienced versus very experienced spine surgeons measures for indications in all cases were the same. However, even if it is the right patient with the right indication for lumbar disc surgery, a good result demands a well-trained surgeon to take out the disc fragment after an exact preoperative planning and using a standard approach. The learning curve in microdecompression surgery can be shortened by training with the surgical microscope on cadaver spines in special training courses. The infection rate can be lowered by careful draping of the microscope and by the use of prophylactic antibiotics. The recurrence rate of a new herniation at the same level and side is a very important complication in lumbar disc surgery, which is discussed in the literature. In most cases another operation, with greater possibilities for complications and scar formation, is necessary. In many cases it is the beginning of a failed back surgery syndrome. Besides a careful intraoperative removal of intradiscal fragments that could cause recurrent herniation, postoperative care with the special program of back school is necessary.

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