Review paper

A review of surgical techniques of lumbar disc herniation

Przegląd technik chirurgicznych stosowanych w leczeniu przepukliny międzykręgowej kręgosłupa lędźwiowego

Natalia Gołębiowska

Department of Neurosurgery and Spine Surgery, Regional Hospital, Kielce, Poland
Head of the Department: Jacek Gołębiowski

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Słowa kluczowe: małoinwazyjne techniki chirurgiczne, dysk międzykręgowy, przepuklina.

Abstract

Lumbar disc herniation is caused by degenerative changes in the intervertebral disc, and is one of the most common causes of disability for people under 45 years old. The most commonly affected regions are the L4/L5 and L5/S1 levels. When conservative treatment does not bring the expected result, surgical treatment is necessary. Fast recovery, early mobilisation, and short hospitalisation is what patients expect nowadays. There are a wide range of surgical techniques available, from open surgeries, such as laminectomy, hemilaminectomy, and microdiscectomy, to minimally invasive surgeries, such as percutaneous endoscopic lumbar discectomy, which are becoming more and more popular. Microdiscectomy is a gold standard in spine surgery for lumbar disc herniation.

Streszczenie

Przepuklina międzykręgowa, która jest efektem zmian degeneracyjnych w dysku międzykręgowym, stanowi jedną z najczęstszych przyczyn ograniczenia sprawności u osób poniżej 45. roku życia. Zwykle dotyczy poziomu L4/L5 i L5/S1. W przypadku niepowodzenia leczenia zachowawczego konieczne jest leczenie operacyjne. Ze względu na tempo życia współcześni pacjenci oczekują krótkiego okresu rehabilitacji, szybkiego powrotu do sprawności fizycznej, a także krótkiego czasu hospitalizacji. Obecnie istnieje wiele metod operacyjnych leczenia przepukliny międzykręgowej – tzw. techniki otwarte, np. laminektomia, hemilaminektomia i mikrodiscektomia, oraz techniki małoinwazyjne, cieszące się coraz większą popularnością, takie jak endoskopowe usunięcie przepukliny międzykręgowej. Złotym standardem leczenia operacyjnego przepukliny międzykręgowej jest mikrodiscektomia.

Introduction

The intervertebral disc is one of the most important components of the vertebral column. Its main function is to absorb the vertical load of the spine, which it fulfils thanks to its binary construction consisting of a centrally located nucleus pulposus and the annulus fibrosus that is surrounding it. Initially in young people the disc has a vascular supply; it becomes avascular in adult patients, and its only nutrition comes from diffusion from the surrounding tissues. Dehydration of the intravertebral disc, alteration in synthesis of collagen, diminished activity of fibroblast (collagen and proteoglycans), microtrauma, and repeated overloading can cause the disc herniation. The symptoms that it causes are among the most common causes of disability among people under 45 years old: low back pain, sciatica, and motor deficits, which play a key role in the qualification for operation [1]. The most commonly affected regions are the L4/L5 and L5/S1 levels.

The latest recommendations indicate that non-surgical treatment, i.e. pharmacotherapy and proper rehabilitation, should be the method of choice for 6–8 weeks. If the symptoms do not recede, surgical treatment is indicated [1, 2]. Patients with the following symptoms should be operated instantly: motor weakness, bladder or bowel dysfunction, and saddle anaesthesia [1, 2]. In case of intolerable pain, urgent surgery may be indicated.

The first laminectomy was performed by William MacEwen and Victor Horsley in about 1887. The first discectomy was performed by the surgeon Fedor Krause in 1908. But it was not until 1934 that Mixter and Barr presented a connection between disc herniation and its symptoms, and suggested laminectomy with discectomy as a surgical treatment [2, 3]. The

most common technique of minimally invasive approach is a modification of Love's fenestration technique, which he described in 1938 [3].

Surgical techniques have developed over the years, and minimally invasive surgery is an ongoing trend. There is a short review of surgical techniques of lumbar disc herniation below. What should be emphasised at the beginning is that the currently recommended extent of discectomy is to perform a conservative discectomy and not an aggressive one, with minimal interference in the disc space [4].

Surgical techniques of lumbar spine herniation

Laminectomy and discectomy

This is the most classic, and now historic, way to operate on a hernia. Indications: motor weakness, sphincter dysfunction, neurological deficit, insufficient improvement after conservative therapy, and advanced degenerative spinal disease or spinal stenosis. Contraindications: pain remission, skin infection in the operated area, contraindications to general anaesthesia [1].

The patient is placed under general anaesthesia, in a prone or knee-chest position. An incision is made in the midline, appropriate to the hernia level. In the next step, the paraskeletal muscles are retracted, and the lamina is exposed. Laminectomy is removal of the lamina on both sides of the vertebra and of the spinal processus. After exposure of the nerve root and the dural sac, the protruding disc is located, and a small incision is made on its surface. Then the degenerated nucleus is removed. The mobility of the nerve root should be checked in the next step.

The patient can be mobilised on the day after the surgery [2, 4].

Hemilaminectomy and discectomy

This method is a modification of the one above but is used very rarely. Hemilaminectomy is removal of a lamina and the ligamentum flavum only on the side on which the hernia is protruding. Indications and contraindications are the same as above. This procedure is intended for patients with a centrally located hernia, with the hernia located beneath the nerve root, or when there are difficulties in orientation in the operating field [2].

The patient can be mobilised on the day after the surgery.

Microdiscectomy

This is a minimally invasive technique of lumbar spine herniation surgery. It is now the most commonly performed type of surgery [5, 6]. Indications and contraindications are similar to those mentioned above. The incision is made in the midline, and it is about 2–3 cm long. The difference between this and the already mentioned procedures is the extent to which the spinal canal is opened – here the fenestration is made, i.e. a removal of a flavum ligament between two adjoining laminae, and in the case of degenerative changes, additional surgical procedures are carried out to reduce oversized joints. Next, the nerve root, the dural sac, and the bulging disc or a sequestration are located. The use of a microscope or dual-lens magnifier with an LED lamp is necessary [7].

The technique of fenestration discectomy is reputed to be minimally invasive, which not only shortens the hospitalisation time, but also the time of the postoperative rehabilitation.

Patient can be mobilised one day after the surgery.

Postoperative complications for the aforementioned techniques include: nerve root damage (1–8%), damage of the dural sac with spinal fluid leakage (0.3–13%), infection (0.9–5%), temporary pain aggravation due to manipulation near the nerve root, and haematoma [1]. The risk of recurrence of disc herniation is about 4% [1].

Percutaneous treatment in lumbar disc herniation

Percutaneous endoscopic lumbar discectomy

The term "endoscopic discectomy" was introduced in 1997 by Foley and Smith. This technique was then improved, and in 2003 the first micro-endoscopic discectomy was performed [6]. Smaller incision, less muscle and paraspinal tissue damage, lower blood loss, shorter hospital stay, less postoperative pain, and shorter recovery time are the advantages of this technique [6, 8].

Indications differ depending on the type of access but are generally small contained herniations. Magnetic resonance imaging (MRI) and computed tomography (CT) scans are crucial to evaluate the morphology of the disc during the qualification process for the operation.

Contraindications are as follows: skin inflammation in the operated area, cauda equina syndrome, large herniations, sequestration, clinically relevant instabilities and spine deformities, and motor deficit [9]. The procedure is performed under general or local anaesthesia with the use of a C-arm.

There are three possible approaches:

– Transforaminal – naturally existing intervertebral foramen is being used, which means that no bony or ligament structures are resected. The patient is positioned in a prone position. The incision is about 1 cm long, and it is made 10–12 cm from the midline. Internal organs must be excluded on the course of the needle by using CT scans that are performed before. The needle is inserted under the C-arm guidance, then it is replaced with a wire, which is a guide

to insert a cannula. Endoscope, forceps, and other tools are inserted through the cannula. Indications include: intraforaminal herniations, lateral herniations, and nerve root canal stenosis. Contraindications include L5/S1 herniations – iliac crest is an obstacle for the needle, large median herniations [9, 10]. This procedure can also be performed under local anaesthesia, which allows verbal contact to be maintained with the patient as well as direct monitoring of motor function.

– Extraforaminal – access similar to the one above – the needle is inserted in the same line as above; the tip of the needle is placed on the pedicle of the caudal lamina on the operated level. Subsequent steps are the same as in the transforaminal approach. Indications include: far lateral herniations, intraforaminal herniations, and intervertebral foramen stenosis, in hernias where there is an increased risk of exiting nerve injury.
– Interlaminar – the incision is made in the midline. The needle is inserted with the tip maximally medial in the interlaminar window in the flavum ligament under fluoroscopic guidance. Then the ligament is cut and the spinal canal is exposed. Then the dural sac, nerve root, and the hernia need to be located, and the degenerated nucleus is removed. Indications include the following: median herniations, L5/S1 herniations, intervertebral foramen stenosis, and synovial cyst [7, 9].

Possible complications include: dural tears, nerve root damage (2.8–17%), haematoma, vessel injury, and infection [10]. Currently the probability of complications after this surgery is higher than after microdiscectomy, but due to lack of randomised controlled trials it is hard to compare these two methods [9]. Rate of recurrence is about 2–20%, depending on the source [9].

Automated percutaneous nucleotomy

Removal of a lumbar disc herniation with use of an automated Nucleotome (Clarus Medical LLC) – an arthroscope-like device with a spinning and cutting end and a suction end. The procedure is carried out under local anaesthesia with the patient lying in a knee-chest position. The puncture is made in a posterolateral line, about 10 cm to the side from the midline. The needle is inserted under fluoroscopic guidance into the intervertebral disc, and then it is replaced with a wire, which is a guide for the cannula. A needle is inserted through the cannula, which pierces the annulus fibrosus. Then the nucleotome is inserted and the nucleus is cut into smaller fragments that are sucked away simultaneously [2, 11]. The whole procedure lasts about 20 min, and the patient can be mobilised immediately afterwards.

Only a small group of patients have indications for this kind of treatment, and a very precise qualification is necessary. Indications include contained disc herniations and small herniations.

Contraindications include sequestration, non-contained disc herniation, cauda equina syndrome, and spinal stenosis [2, 11].

Possible complications include nerve root damage, vessel injury, and infection.

Short time of the procedure, the fact that it can be performed ambulatorily, and the short recovery time are the major advantages of nucleotomy. The reported success rate is rather low: about 29–75% depending on the source [11].

Nucleoplasty – coblation

Nucleoplasty was introduced in 2000, and it is dedicated to a small group of patients with a small, contained lumbar herniation [11]. The procedure is performed ambulatorily under local anaesthesia, with the patient lying in a prone position. The next step is to place a needle from a posterolateral approach in the middle of the disc space under the guidance of C-arm fluoroscopy.

Discography is performed in order to exclude annular tears, which are a contraindication to proceed with this therapy. If there are none, a specific catheter with an electrode on its tip is inserted into the disc space. The electrode creates a plasma field with a low temperature (40–70°C), which creates a small channel in the disc space but does not destroy surrounding tissues. This process of tissue ablation and coagulation breaks down the molecules to the H_2 and CO_2 gas that is evacuated and a small channel is created. It is important to change several times the positioning of the working tip inside the nucleus pulposus under X-ray control. Usually there are six channels created, which allows the disc volume to be reduced by about 10% to 20% [12].

Contraindications: ruptured disc, spinal stenosis, intervertebral foramen stenosis, spinal instability [13].

Possible complications include discitis, haematoma, nerve root damage, and lower limb numbness. Overall risk of complications is about 1.5% [12, 14]. Proper patient selection is essential for successful nucleoplasty. The success rate is about 62–70% [11, 12].

Percutaneous laser discectomy

The first percutaneous laser discectomy was performed in 1986 by Choy *et al.* [15]. The idea of the procedure is to decrease pressure in the disc space by evaporating the main component of the nucleus, i.e. water, and by this to decompress the nerve root and to reduce pain [11, 16].

The procedure is performed ambulatorily, under the local anaesthesia, with the patient lying in a prone position. Under the guidance of C-arm fluoroscopy, a needle with an optic fibre running through it is

placed in the intervertebral disc. Laser energy evaporates water in the nucleus pulposus and heat created by it desensitises intradiscal nociceptors and thus reduces pain [17].

Currently used lasers include the following: Nd:YAG laser (neodymium-doped yttrium aluminium garnet), KTP laser (potassium-titanium-phosphorus), and Ho:YAG (holmium yttrium-aluminium-garnet) laser, which generates pulses of energy that reduce the temperature rise in the adjacent tissue and thus prevent its destruction [17].

The procedure is dedicated to patients with radicular pain resistant to conservative therapy, contained single-level herniation [17]. Laser discectomy reduces intradiscal pressure by as much as 57% [15].

Contraindications: hernia with sequestration, neurological deficit, spinal stenosis, previous surgery at the same disc level, and advanced degenerative spinal disease [16, 17].

Possible complications include the following: discitis, nerve root damage (0.46%), and haematoma (1.7%) [11, 17]. Rate of complications is less than 1% [11]. Success rate is more than 80% [11].

Intradiscal electrical thermocoagulation (IDET)

The first IDET was performed in the late 1990s. Its purpose is to treat lumbar spine pain caused by small contained hernias or a ruptured annulus [11, 18]. Nucleus pulposus and annulus fibrosus are built of collagen. Use of high temperature (up to 90°C) causes degeneration of its fibres and their shrinkage, which causes collagen contraction by up to 35% of its original size and thus decompression of the nerve root [11]. In addition, this thermal effect helps to enhance the integrity of a weakened annulus and destroys the nociceptors, which helps to reduce pain [11, 18].

The procedure is performed ambulatorily under local anaesthesia. A special kind of catheter is inserted, under C-arm control, into the disc space, and it should be placed circumferentially around its inner surface. Next, the electrode is heated to 65°C, and this temperature is maintained for one minute, and then it is increased by 1°C every 30 s, up to 80–90°C [11]. Collagen denaturation takes place between 60 and 65°C, and this temperature was found 2 to 4 mm within the catheter end [11].

Indications: lumbar pain without leg pain, small contained hernias obliterating no more than 30% of the spinal canal, normal disc height [11].

The latest research has revealed low effectiveness of this method [18].

Chemonucleolysis

Chemonucleolysis is also one of the procedures in which the main goal is to reduce the disc volume. It was performed for the first time in 1975 [19]. An enzyme, chymopapain, is injected into the nucleus, where proteoglycans and glycoproteins (the main components of the nucleus, responsible for water retention) are hydrolysed by the enzyme [2]. Reduction of water content and loss of those substances causes shrinkage of the nucleus and thus reduction of the pressure on the nerve root. Another enzyme that is used, aprotinin, dissolves mucopolysaccharides and thus reduces oncotic pressure in the nucleus.

The procedure is performed ambulatorily under local anaesthesia, with the patient lying in a knee-chest position. The nucleus is punctured with a needle under the C-arm guidance. The tip of the needle has to be placed in the centre of the disc. There are three possible approaches: interlaminar, transforaminal, and through the dural sac in the midline. After placement of the needle, discography is performed to exclude annular tears what would be a contraindication to continue the procedure. Next, a small dose of chymopapain is injected, no more than 1–2 cc [19]. After the procedure patient observation is necessary to exclude allergic reaction.

Indications: small lumbar contained herniation, no neurological deficits [11, 19].

Contraindications include the following: allergic sensitivity to papain or papaya, previous disc or vertebral infection, neurological deficit, previous surgery at the same disc level, and spinal stenosis [19].

Possible complications include the following: anaphylactic shock, enzyme leakage and damage of the nerve root or vessels, and acute transverse myelitis [2, 19].

Because of the risk of complications, this procedure is now no longer performed [1].

Conclusions

Minimalism in spinal medicine can be observed for many years. Fast recovery, early mobilisation, and short hospitalisation is what patients expect nowadays. Microdiscectomy is a gold standard in spine surgery for lumbar disc herniation. Percutaneous endoscopic lumbar discectomy is becoming more and more popular, and new indications are being included. A great disadvantage of this technique is still a long learning curve. Only 10–15% of patients can be considered for percutaneous intradiscal procedures [1]. These techniques are still very controversial procedures for lumbar spine surgery.

Conflict of interest

The author declare no conflict of interest.

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Address for correspondence

Natalia Gołębiowska
Department of Neurosurgery and Spine Surgery
Regional Hospital
ul. Grunwaldzka 45, 25-001 Kielce, Poland
Phone: +48 668 111 142
E-mail: natalia.golebiowska@yahoo.com