Charles University

Faculty of Physical Education and Sports

Literature Review

Effectiveness of conservative and microdiscetomy treatment for patients with lumbar disc herniation

Master's thesis

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Declaration

I declare that this Master's thesis has been based entirely on my own individual work, attained with knowledge from various books, articles and journals. All the information used for the development of this work has been taken from the list of literature that exists in the end of this Master's thesis.

Prague, December 2013 Denis Homotetski

Acknowledgement

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Abstract

Title

Effectiveness of conservative and microdiscetomy treatment for patients with lumbar disc herniation

Background

Lumbar disc herniation is a common cause of the radiating leg pain and related disabilities that affects people mostly in the middle age. Patients that suffer from lumbar disc herniation respond well to conservative treatment, but for some amount of them surgery could be considered if conservative care is failed after 6 weeks. Although variety of conservative methods that common available in the treatment of lumbar disc herniation, there is conflicting evidence that one type of treatment is clearly superior to others and disagreement over superiority of either surgical intervention or longer conservative treatment for patients with persistent symptoms lasting more than 6 weeks without serious neurological deficit.

Aim

The main purpose of this thesis is to assess the efficacy of main types of conservative and surgery treatments of the lumbar disc herniation and factors that influence clinical outcomes in patients undergoing this treatment.

Method

This thesis is a literature review, reviewing articles from relevant journals and books. The relevant sources were searched and collected from database of PubMed, Cochrane library and ScienceDirect from beginning of 2012 to the middle of 2013.

Results

According to reviewed studies from variety of conservative treatments only epidural corticosteroid injection showed significantly improvement regarding to pain relief. Patients undergoing conservative care and surgical intervention improve over time, however patients undergoing surgical intervention has faster reduce of pain in the first 6 month compared to conservative treatment. Effectiveness of microdiscectomy is comparable with other surgical techniques, but has less post-operative complication

Conclusion

Patients with lumbar disc herniation whose symptoms have not improved during 6-12 weeks, the most appropriate treatment option for them in reducing of symptoms can be considered the surgery intervention.

Keywords

Lumbar disc herniation, sciatica, radiculopathy, conservative treatment, surgery treatment, microdiscectomy.

Abstrakt

Název

Účinnost konzervativní léčby a mikrodiskektomie u pacientů s výhřezem lumbální ploténky.

Úvod

Lumbální hernie disku je častou příčinou bolesti vystřelující do nohy i přidružených potíží postihujících zejména osoby středního věku. U pacientů s výhřezem lumbální ploténky sice zabírá konzervativní léčba, ale u některých lze přesto zvažovat chirurgický zásah v případech, kdy konzervativní postup zůstává po 6 týdnech bez účinku. Přestože ke zvládnutí lumbální hernie disku je k dispozici celá řada konzervativních metod, názory se různí, pokud jde o průkaz, že jedna z nich je nepochybně lepší než všechny ostatní, a přetrvává rozpor v tom, co je pro pacienty výhodnější: operace nebo delší konzervativní léčba tam, kde příznaky trvají déle než 6 týdnů bez vážnějšího neurologického deficitu.

Cíl

Hlavním účelem této práce je zhodnotit účinnost konzervativní i chirurgické léčby při výhřezu lumbální ploténky a posoudit faktory, které ovlivňují klinické výsledky u takto léčených pacientů.

Metodika

Tato práce přináší přehled statí uveřejněných v odborných časopisech a knihách. Relevantní zdroje byly vyhledávány a shromažďovány z databází PubMed, Cochrane Library a ScienceDirect v době od začátku roku 2012 do poloviny roku 2013.

Výsledky

Podle zkoumaných studií, ze všech různých metod konzervativní léčby přinesly významnou úlevu od bolesti pouze epidurální injekce kortikosteroidů. Zlepšení se po čase projeví u pacientů léčených jak konzervativně, tak chirurgicky. Nicméně ve srovnání s konzervativní léčbou se úleva od bolesti v prvních šesti měsících dostavuje po chirurgické operaci dříve. Mikrodiskektomie má sice podobné účinky jako jiné chirurgické postupy, ale zato méně pooperačních komplikací.

Závěr

U pacientů s výhřezem lumbální ploténky a s potížemi, které ani po 6-12 týdnech neustupují, je nejvhodnější uvažovat o chirurgickém řešení příznaků.

Klíčová slova

Výhřez lumbální ploténky, ischias, radikulopatie, konzervativní léčba, chirurgická léčba, mikrodiskektomie.

Table of contents

List of figures:

List of tables:

List of abbreviations:

AF-Annulus fibrosus

ADL- Activities of daily living

CPK- Creatine phosphokinase

CSA- Cross-sectional area

CT- Computed tomography scan

CESI- Caudal epidural steroid injection

EMG- Electromyography

ESI- Epidural steroid injection

IVD- Intervertebral disc

IL- Interleukin

IESI- Interlaminar epidural steroid injection

LDH- Lumbar disc herniation

LRS-Lumbar radicular syndrome

MRI- Magnetic resonance imaging

MED- Micro-endoscopic discectomy

MC- Microsurgical discectomy

MAPN- Minimally invasive microscopic procedure

NP-Nucleus pulposus

NO- Nitric oxide

NSAIDs- Non-steroidal anti-inflammatory drugs

PT- Physiotherapy

ROM- Range of motion

RCT- Randomized controlled trial

RC-Radiologic control

SLRT- Straight leg raising test

SPORT- Spine Patient Outcomes Research Trial

TrP- Trigger point

TNF- Tumor necrosis factor

TESI- Transforaminal epidural steroid injection

VAS- Visual analogue scales

Introduction

Low back pain affect up to 80% of people in the modern word at some point in their lives, creating high rates of activity limitation, work absence, impaired quality of life and the need for medical care [26]. Lumbar disc herniation is a common cause of low back and radicular leg pain that tends to improve spontaneously over time. Firstly disc herniation was described in 1934 by Mixter and Barr and they were the first clinicians to treat lumbar disc herniation surgically by performing an open laminectomy and discectomy.

A majority of the patients suffering from lumbar disc herniation experience a positive natural history and respond well to conservative treatment, but a certain amount of patients are referred to surgery if conservative treatment has failed [26]. Some clinicians claim that surgical intervention in management of lumbar disc herniation could be avoided if only continue conservative management for longer period before considering surgery. On the contrast, it is known that long lasting period of pain can lead to functional restriction, anxiety and depression.

There is consensus that conservative management of lumbar disc herniation has to come before surgical intervention (except of the emergency cases), although the effectiveness and duration of conservative treatment have not determined yet. Therefore, there is no enough evidence that one type of conservative treatment is clearly superior to others for patients with lumbar disc herniation.

In the last decades diagnostic tools and surgical techniques have developed dramatically and patients undergoing surgical intervention in management of lumbar disc herniation usually feel immediately improving in their symptoms and usually dismissed from the hospital within 24 hours of surgery and return to work within 2–6 weeks [10]. However, consensus regarding to surgical intervention is lacking as to whether surgery is useful or not in patients who has their persistent complaints which lasting more than 6-12 weeks without serious neurological deficit.

As a physiotherapist who treating patients that suffers from lumbar disc herniation, we have to apply benefits and to know restrictions of most available conservative methods and learn to define the optimal time and appropriate conditions for surgical intervention in management of lumbar disc herniation.

1. General overview of the lumbar spine

1.1 Spinal column

The spinal column (also known as vertebral column) is the central bony pillar of the body that consists of 33 vertebrae: 24 movable vertebrae (7 cervical, 12 thoracic, and 5 lumbar) followed by the sacrum (5 fused sacral vertebrae) and the coccyx (4 fused coccygeal vertebrae). Because it is segmented and made up of vertebrae, joints, and pads of fibrocartilage called intervertebral discs, it is a flexible structure [89]. Each vertebra is connected to the adjacent vertebra by an intervertebral disc and a number of ligaments. The intervertebral discs form about one quarter the length of the column [71].

Although vertebrae have regional differences, they all maintain common structure. A typical vertebra consists of a rounded body anteriorly and a vertebral arch posteriorly. These enclose a space called the vertebral foramen, through which run the spinal cord and its coverings. The vertebral arch consists of a pair of cylindrical pedicles, which form the sides of the arch, and a pair of flattened laminae, which complete the arch posteriorly. The vertebral arch gives rise to seven processes: one spinous, two transverse, and four articular processes [17].

Each aspect of a vertebra has a major function. The vertebral body serves as the weight-bearing aspect, the bilateral articular superior and inferior processes determine the direction of motion and restrict abnormal movement, the vertebral arch encases the spinal cord and its coverings, and the spinous and transverse processes serve as bony levers for muscle and ligament attachment [71].

The spinal column is a complex, and remarkable, mechanical structure. It serves to protect the spinal cord, provision of movement and transmits the weight of the upper body to the pelvis [89]. The spinal column has several normal curves (Fig. 1). In the cervical and lumbar regions the spine is anteriorly convex (lordotic), and in the thoracic and sacral areas it is posteriorly convex (kyphotic). Collectively, these curves form a stable system that maintains the center of gravity in a balanced state [17].

The most critical part of the spinal column in aspect of injury is the lumbar spine. The lumbar spine is the section of spinal column between the thorax and the sacrum and consists of five separate vertebrae named L1 to L5. As compared to other parts of spinal column (cervical or thoracic) lumbar spine is the maximally loaded part and has the maximal mobility at the same time [52].

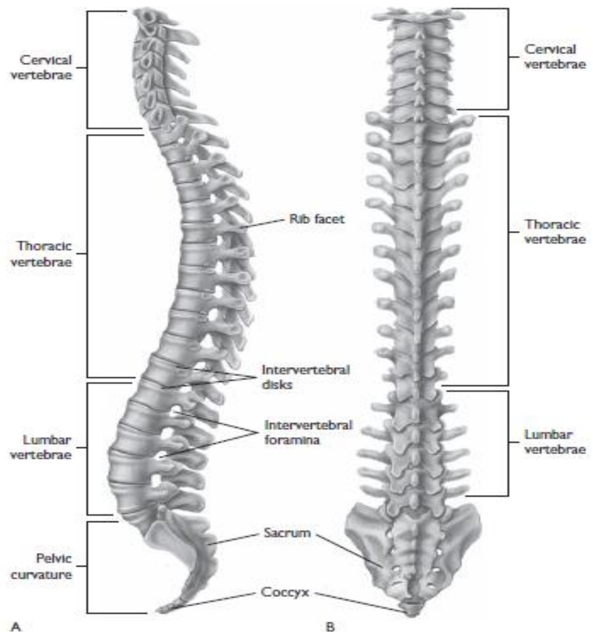

Figure 1. A. Lateral view of the major regions of the spine.
B. Posterior view of the major regions of the spine [89].

1.2 Biomechanics of the Lumbar spine

The spine is mechanical structure where the curve of the spine in sagittal plane provides flexibility for motion and axial loading capacity of carrying and at the same time maintains adequate stiffness and stability for upright posture. Any changes of contours in normal sagittal plane can have a significant effect on the mechanical behavior of the spine [34].

By lordotic posture, the lumbar spine is protected to an appreciable extent from compressive forces and shocks [72]. The lordosis naturally results from the shapes of the vertebrae and discs of the lumbar spine [52]. The primary weight-bearing components of the spine are vertebral bodies and intervertebral discs.

The vertebrae become larger in shape and thickness from the cervical region down through the lumbar region. The vertebrae of the lumbar spine are the larger and thicker than cervical and thoracic vertebrae in the body because their load-bearing surface areas are greater. The pedicles of lumbar vertebrae are longer and wider than those in the thoracic spine. The spinous processes are horizontal and more squared in shape [28].

The discs increase in size as they descend the column. The lumbar intervertebral discs having an average thickness of 10mm thick and 4 cm in diameter. The greater anterior widths of the intervertebral discs in the lumbar region reflect the curvature of this area. The L5-S1 intervertebral disc is wedge shaped, its posterior height typically about 7mm less than its anterior. The L5 vertebral body also is wedge shaped, its posterior height typically 3 mm less than its anterior [52].

Lumbar curvature (Fig.2) is calculated as the angle formed between the surface of the vertebral body of L1 and that of the sacrum. Sacrum is the bottom of the lumbar spine and is angled at about 30° to the horizontal. The population means value of this angle is 50°, although in children it is increased to 67° and in young males to as much as 74° depending on posture type [52].

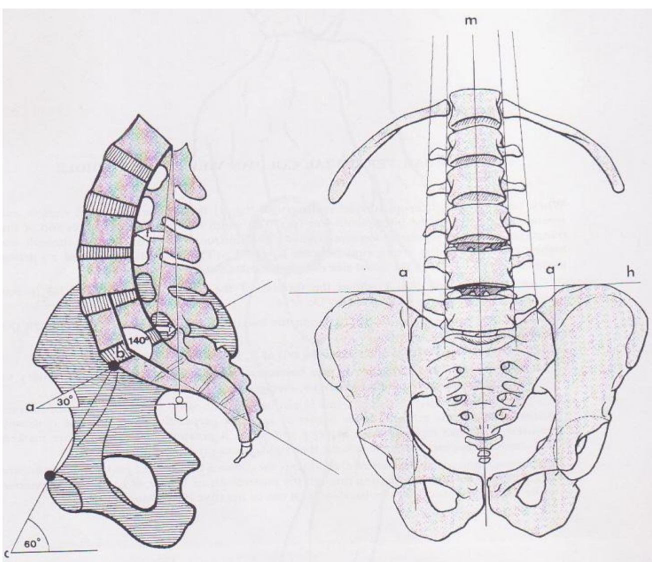

Figure 2. The Lumbar vertebral column [35].

1.3 Functional unit of the spine (motion segment)

The spine comprises a static, changeless element – the vertebral bodies – and an elastic mobile component the three-joint complex, consisting of the intervertebral disc and the two posterior facet joints [3]. Each level of the spine is a three-joint complex with load bearing sharing between the three joints and considered as functional unit of the spine. Functional unit (Fig. 3) contains the articulated triad- consisting of the intervertebral disc, which forms the symphysis joint between the bodies of adjacent vertebrae, and two facet joints (also called zygapophyseal or apophyseal joints), where the inferior articular process on either side of the upper vertebrae come together with the superior articular process on either side of the lower vertebrae [52, 53].

Movements that permitted between adjacent vertebrae in the cervical, thoracic and lumbar portions of the spine depend on the structural differences of the vertebrae and the ribs. Within these regions, two adjacent vertebrae, and the intervening soft tissues between them, are known as a motion segment [28]. Spinal motion segments represent the smallest segments of the spine exhibiting biomechanical characteristics similar to those of the entire spine [23]. The motion segment is considered to be the functional unit of the spine.

Compression forces in the lumbar spine are transmitted between adjacent vertebrae by intervertebral disc and two facet joints. The intervertebral disc is the major anterior load-bearing structure that carries approximately 80% of the axial loading and the facet joints distribute the remaining 20%. The facet joints stabilize the motion segment in flexion and extension and also protect the disc from excessive torsion [3].

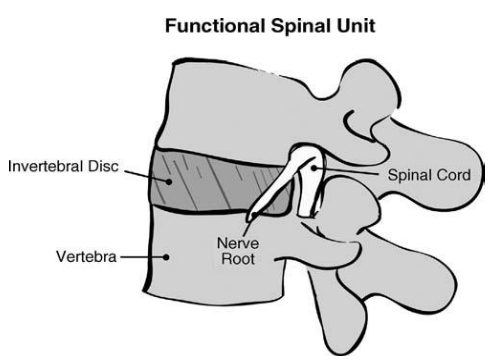

Figure 3. The functional spinal unit consisting of two vertebrae and one intervertebral disc [54].

1.4 Movements of the lumbar spine

The principal movements exhibited by the lumbar spine and its motion segments are flexion, extension, axial rotation and lateral flexion. There is considerable individual variability in the range of motion segments of the lumbar spine. Range of motions in the lumbar spine depends in the shape of the facet joints, tightness of the ligaments, intervertebral discs and size of the vertebral [52].

In the lumbar spine, flexion and extension motions increase in range from the top to the bottom [54]. This is the reason that greatest motion in the lumbar spine occurs between L5-S1. The maximum ROM for flexion of lumbar spine is 60°. Extension is limited to 35°. Lateral flexion is approximately 20°. Axial rotation is 5° [28].

1.5 The intervertebral disc

1.5.1 Srtucture of the Intervertebral disc

The intervertebral disc (Fig.4) comprises three structures: nucleus pulposus, annulus fibrosus and the vertebral endplates. The central part of the disc, the nucleus pulposus, is gelatinous structure, which consists of various proteoglycans, type II collagen fibers and non-collagenous proteins. The major proteoglycan of the disc is aggrecan, which, because of its high anionic glycolsamino-glycan content provides the osmotic properties needed to resist compression [73]. Water constitutes 70 to 80% of the nucleus. The nucleus fills 30 to 50% of the total disc cross sectional area, and it’s located more posterior than central [66]. No blood vessels or nerves penetrate the nucleus.

The annulus fibrosus encapsulates the nucleus pulposus in its centre and divided into inner and outer portions. In the inner annulus fibrosus, there is a transition to collagen II that, together with increasing proteoglycan concentration, gives rise to a less fibrous and less organized structure. The highly organized outer collagenous portion of the annulus fibrosus consist of distinct lamellae, which are composed of bundles of collagen I fibers oriented at oblique angles that alternate within each consecutive lamella to form an angle varying between 40° and 70° to the vertical axis and making this structure more sensitive to rotational strain than to compression, tension, and shear [73]. The outer layers of fibers blend with the posterior longitudinal ligament. The anterior and lateral portions are approximately twice as the posterior portion, where the layer appear to be narrower and less numerous [66].

Two thin endplates of hyaline cartilage extend superiorly and inferiorly over the inner AF and NP to interface with the vertebral bodies. They are approximately 1mm thick at its outer edge and become thinner toward its center [88]. Their function is to regulate nutrient diffusion between the disc and the vertebral bodies. In the outer regions of the AF, collagen fibers anchor directly into the vertebral bone.

The adult disc is the largest avascular structure of the body, but it has some nerves, mainly restricted to the outer lamellae, some of which terminate in proprioceptors [74].

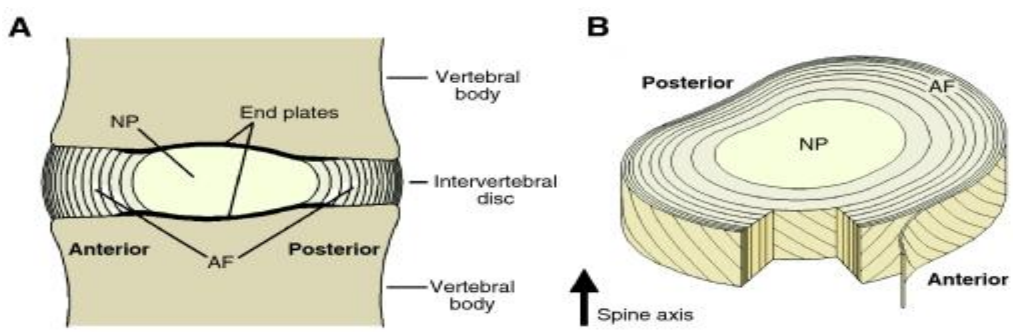

Figure 4. Schematic representations of the adult intervertebral disc
(A) Mid-sagittal cross-section showing anatomical regions.
(B) Three-dimensional view illustrating AF lamellar structure [73].

1.5.2 Biomechanics of the intervertebral disc

The primary function of the nucleus pulposus is to redistribute an applied load to the remainder of the surrounding intervertebral disc, while the annulus fibrosus is the primary load-bearing component of the intervertebral disc [40].

Intermittent changes in posture and body position after internal disc pressure, causing a pumping action in the disc. The inflow and outflow of water transport nutrients in and flushes metabolic waste products out, basically fulfilling the same function that the circulatory system provide for vascularized structures within the body [1].

The intrinsic swelling pressure of the unloaded disc is approximately 10 N/cm2. As the applied force increases above this base level, disc hydration decreases as water is expressed from the disc and consequently the net concentration of proteoglycans increases [1]. The rate of fluid expression is slow, due to the low intrinsic permeability of the disc. A net daily fluid loss of approximately 10–20% has been observed in vivo and in vitro [95]. Fluid lost during daily loading is regained overnight during rest, and it has been postulated that this diurnal fluid exchange is critical for disc nutrition. The degree of discal compression depends on the weight imposed and rate of loading. A 100 kg axial load (Fig. 5) can compress a disc by 1.4mm and cause a lateral expansion of 0.75mm [28].

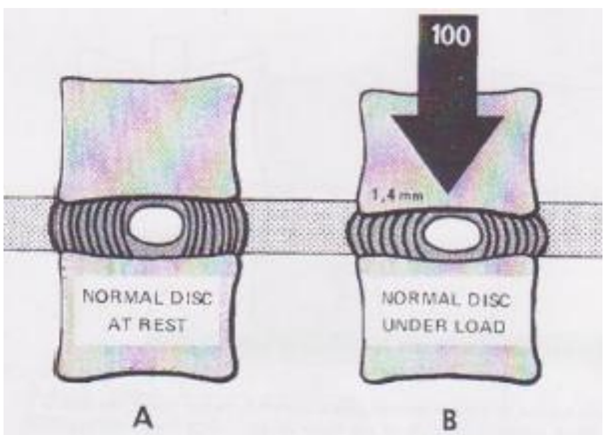

Figure 5. Compression applied to the disc [35].

Intravertebral disc with the facet joints transmits all the compressive loads to which the spine is subjected. This includes different types of loads and stresses, like dynamic, static, torsional loads, and tensile, shear stresses and a combination of tensile, compressive and shear stresses [11, 54].

In the healthy disc, axial loads are borne by hydrostatic pressurization of the nucleus pulposus, resisted by circumferential stresses in the annulus fibrosus. Pressure within the nucleus is approximately 1.5 times the externally applied load per unit disc area. As the nucleus is incompressible, the disc bulges under load and considerable tensile stresses are generated in the annulus. The stress in the annulus fibers is approximately 4–5 times the applied stress in the nucleus [11].

The nucleus pulposus is roughly spherical. The IVD has 6 degrees of freedom, allowing independent angular motion about, and independent translation along each of three anatomical axes [54]. This includes: flexion and extension, lateral flexion, gliding in the sagittal plane, gliding in the frontal plane, rotation right and left. Each of these movements has a small range and sizeable movements are only obtained by the simultaneous participation of multiple intervertbral joints [35].

Flexion, extension and lateral flexion of the spine produce mainly tensile and compressive stresses in the disc (relate to nucleus pulposus), whereas rotation produces mainly shear stress (relate to annulus fibrosus) [54].

1.6 Ligaments of the spine

The ligaments surrounding the spine guide segmental motion and contribute to the intrinsic stability of the spine by limiting excessive motion [11].

Ligamentous support of the spine is provided by the anterior longitudinal ligament and posterior longitudinal ligament that run the length in front and in back of the spine [71]. These longitudinal ligaments are located close to the vertebrae and reinforced the intervertebral disc anteriorly and posteriorly. In the lower lumbar level the posterior longitudinal ligament narrows considerably [11].

Several ligaments run between the vertebrae (intertransverse ligaments, interspinous ligaments, supraspinous ligament, and facet capsulary ligaments). These ligaments resist forces that would pull the spine out of alignment. Another important supporting structure of the spine is the ligamentum flavum. This ligament connects the laminae of the adjacent vertebrae and provides support to the posterior elements of the spine and helps form the spinal canal. The ligamentum flavum is in tension even when the spine is in anatomical position, enhancing spinal stability. This tension creates a slight, constant compression in the intervertebral discs. [35]

1.7 Muscles of the spine

The spine is an elastic column, with enhanced stability due to the complex curvature of the spine (kyphosis and lordosis), the support of the longitudinal ligaments, the elasticity of the ligamentum flavum, and most importantly the active muscle forces [11].

The spatial distribution of spine muscles generally determines their function. The trunk musculature can be divided functionally into extensors and flexors. The main flexors are the abdominal muscles (rectus abdominis, internal and external oblique and transverse abdominal muscle) and the psoas muscles. The main extensors are the sacrospinalis group, transversospinal group, and short back muscle group. Symmetric contraction of extensor muscles produces extension of the spine, while asymmetric contraction induces lateral bending or twisting. The most superficial layer of trunk muscles on the posterior and lateral walls are broad, connecting to the shoulder blades, head and upper extremities (rhomboids, latissimus dorsi, pectoralis, and trapezius)[11].

Trunk muscles have very important role in controlling stability of the lumbar spine during different activities [28]. Some lower trunk muscles connect to a strong superficial fascial sheet, the lumbodorsal fascia, which is a tensile-bearing structure attached to the upper borders of the pelvis e.g. transversus abdominis [11]. Muscles like abdominal and multifidus plays important function and their dysfunction lead to increase shear forces on the lumbar facets and increased lumbar lordosis [28].

1.8 Neural structures

The spinal canal contains the spinal cord and the nerve roots. The spinal cord lies within a bony canal formed by adjacent vertebrae and soft tissue elements. The nerves exit the spine through the intervertebral foraminae. The spinal nerve roots, which exit from the spinal canal, connect the central nervous system and the peripheral nerves [17].

There are 31 pairs of spinal nerves, 8 cervical, 12 thoracic, 5 lumbar, 5 sacral and one coccygeal. Each spinal nerve formed by the convergence of a dorsal root and a ventral root usually within the intervertebral foramen. Just distal to this union, each spinal nerve divides into a dorsal ramus (posterior primary division) and a ventral ramus (anterior primary division). The dorsal root of each spinal nerve transmits sensory fibres from the spinal nerve to the spinal cord. The ventral root largely transmits motor fibres from the cord to the spinal nerve but may also transmit some sensory fibres [17].

The spinal cord, which is the continuation of the brain stem, extends from the foramen magnum to the L1-L2 level. The lower tip of the spinal cord the conus medullaris is a cone-shaped structure pointing downward and because it is shorter than the spinal column, its lower segments do not correspond with the vertebrae at the same level. Below the L1-L2 level the spinal canal contains the lumbar and sacral nerve roots that run within the vertebral canal where they are largely enclosed in the dural sac. Within the dural sac, the lumbar nerve roots run freely, mixed with the sacral and coccygial nerve roots to form the cauda equine [10].

The anatomy of the nerve root differs from that of the peripheral nerves. The nerve root lacks an epineurium and therefore has one less layer of protection around it. Within the nerve root itself there is a reduced collagen content and the nerve fibres run in a more parallel orientation. All of the above factors make the nerve root more susceptible to mechanical deformation [19].

All the spinal nerves below the cervical level exit at the same level as the corresponding vertebrae. The nerve roots branch off the spinal cord higher than their actual exit through the intervertebral foramen. This means that the spinal nerves must often pass downwards adjacent to the spinal cord before exiting through the intervertebral foramen. This leaves the nerve exposed to the risk of compression by protruding disc material (Fig. 6). Therefore (Fig. 6) it is possible to have a compression of the L5nerve root at the L4-5 disc space [10].

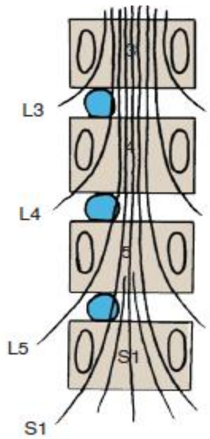

Figure 6. Posterior views of vertebral bodies in the lumbar regions showing the relationship that might exist between the herniated nucleus pulposus and the spinal nerve roots [71].

The lumbosacral plexus arise from the lumbar and sacral segments of the spinal cord, which is composed of ventral rami L2 through S2 (with contributions from Ll and S3). The major branches of this network are the femoral, obturator, gluteal, sciatic, common peroneal (fibular) (and its branches), and tibial nerves [17].

The sciatic nerve (L4 to S3) is the body's largest nerve. It leaves the pelvic cavity through the greater sciatic foramen, below the piriformis muscle and passes through the gluteal region into the thigh, where it divides into its two major branches, the common peroneal nerve and the tibial nerve. The sciatic nerve supplies the skin o f the posterior and lateral border of the leg and foot as well as the muscles of the leg and foot and the posterior muscles of the thigh [17].

1.9 The Spinal Stabilization System

One of the important causes of low back pain is clinical instability. It believed that clinical instability causes the loss of normal pattern of spinal motion that leads to pain and/or neurologic dysfunction, although there is some controversy concerning its definition. The basic concept of spinal instability is that abnormally large intervertebral motions cause either compression and/or stretching of the inflamed neural elements or abnormal deformations of ligaments, joint capsules, annular fibers, and end-plates, which are known to have significant density of nocioceptors. In both situations the abnormally large intervertebral motions may produce pain sensation [59].

Panjabi redefined spinal instability in terms of a region of high flexibility or laxity around the neutral position of spinal segment called the neutral zone (Fig.7). The extent of the neutral zone increases following intervertebral disc degeneration, intersegmental injury and repetitive cyclic loading and decreased with simulated muscle forces across a motion segment. The neutral zone is considered to be a clinically important measure of spinal stability function [56].

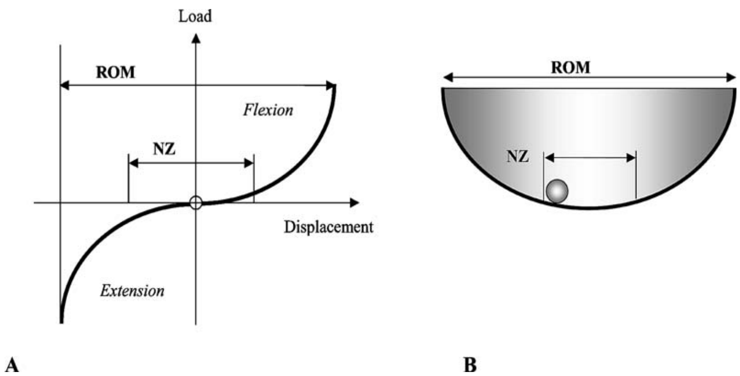

Figure 7. Load–displacement curve. (A) Spine segment subjected to flexion and extension loads exhibits a nonlinear load displacement curve, indicating a changing relationship between the applied load and the displacements produced. Addition of NZ parameters, representing laxity of the spine segment around neutral position, to the ROM parameter better describes the nonlinearity of the spinal characteristics. (B) A ball in a bowl is a graphic analogue of the load–displacement curve [60].

The spinal stabilizing system is conceptualized as consisting of three subsystems.

- The passive musculoskeletal subsystems include vertebrae, facet articulations, intervertebral discs, spinal ligaments, and joint capsules, as well as the passive mechanical properties of the muscles.
- The active musculoskeletal subsystem consists of the muscles and tendons surrounding the spinal column.
- The neural and feedback subsystem consists of the various force and motion transducers, located in ligaments, tendons, and muscles, and the neural control centers. These passive, active, and neural control subsystems, although conceptually separate, are functionally interdependent.

The normal function of the stabilizing system is to provide sufficient stability to the spine to match the instantaneously varying stability demands due to changes in spinal posture, and static and dynamic loads. The three interrelated subsystems works together to achieve this goal and maintain spinal stability [59].

1.9.1 Spinal stability through muscular activity

By using a mechanical modeling approach Bergmark hypothesized the presence of two muscle system that act in the maintenance of spinal stability and divided the musculature acting on the lumbar spine into two groups: local and global [75].

The global muscle system consists of large torque producing muscles that act on the trunk and spine without directly attaching to it. These muscles include rectus abdominus, obliquus abdominis externus and the thoracic part of lumbar iliocostalis and provide general trunk stabilization, but are not capable of having a direct segmental influence on the spine.
The local muscle system consists of muscles that directly attach to the lumbar vertebrae, and are responsible for providing segmental stability and directly controlling the lumbar segments. By definition lumbar multifidus, psoas major, quadratus lumborum, the lumbar parts of the lumbar iliocostalis and longissimus, transversus abdominis, the diaphragm and the posterior fibres of obliquus abdominis internus all form part of this local muscle system.
There is a significant neurophysiological difference in the timing of contraction of these two muscle systems. When loads are predictable, the local system contracts prior to the perturbation regardless of the direction of movement whereas the global system contracts later and is direction-dependent [56]. Functionally, the global musculature was felt to balance the outer loads on the body, enabling the local system to maintain force control within the lumbar spine and center postural activity at a range within the load tolerance of the spinal structures [75].

Cholewicki and McGill developed a comprehensive mathematical model to estimate the mechanical stability of the human lumbar spine in vivo, taking into account the external load on the body [60] and reported that the lumbar spine is more vulnerable to instability in its neutral zone and at low load when the muscle forces are low [75]. Young, healthy subjects were tested by performing variety of tasks involving trunk flexion, extension, lateral bending, and twisting. They found that if the system was challenged by a sudden increase in the external load, e.g. a miss step or an awkward spinal movement, then the spine may be at risk for injury while lightly loaded. While the global muscle system provides the bulk of stiffness to the spinal column, the activity of the local muscle system is considered necessary to maintain the segmental stability of the spine [60].

It is proposed that co-contraction of local system muscles such as transversus abdominis, diaphragm and lumbar multifidus result in a stabilizing effect on the motion segments of the lumbar spine, particularly within the neutral zone, providing a stable base on which the global muscles can safely act. The segmental stabilizing role of lumbar multifidus, with separate segmental innervation, acts to maintain the lumbar lordosis and ensure control of individual vertebral segments particularly within the neutral zone. The deep abdominal muscles are primarily active in providing rotational and lateral stability to the spine via the thoraco-lumbar fascia, while maintaining levels of intra-abdominal pressure [56].

Researches hypothesized that intra-abdominal pressure (Fig. 8) works like a balloon inside the abdominal cavity to support the adjacent lumbar spine by creating a tensile force that partially offsets the compressive load. The intra-abdominal pressure mechanism increase prior to the lifting of a heavy load and primarily controlled by the diaphragm, transversus abdominis and pelvic diaphragm. Increased intra-abdominal load provides a stiffening effect on the lumbar spine during loading and this mechanism is very useful to prevent the spine and disc protrusion under compressive load [28].

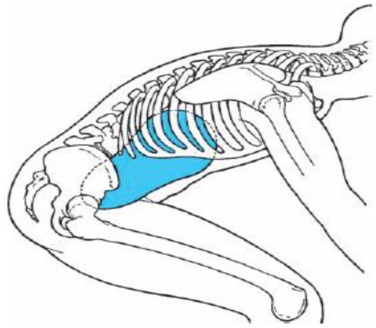

Figure 8. Intra-abdominal mechanism. Intra-abdominal pressure which often increases during lifting, contributes to the stiffness of the lumbar spine to help prevent buckling [28].

2. Overview of Lumbar disc herniation

Herniation is defined as a localized displacement of disc material beyond the limits of the intervertebral disc space. Herniation of an intervertebral disc occurs when the outer layer of the disc, the annulus fibrosus ruptures and allows the inner part of the disc, the nucleus pulposus to leak out of the tear into the spinal canal [24].

Sciatica secondary to lumbar disc herniation caused by an irritation of the lower lumbar nerve roots as a result of mechanical compression and/or chemical irritation by substances released from the nucleus pulposus, known by range of terms in the literature, such as lumbosacral radicular syndrome, radiculopathy, nerve root pain [29, 36].

2.1 Epidemiology and Natural History

Lifetime prevalence of a major episode of low back pain ranges from 60% to 80%, but only 10% of these episodes are accompanied by sciatica [67]. Sciatica lasting longer than two weeks with a lifetime prevalence of varies between 1% and 3% [36, 67]. Symptomatic lumbar disc herniation is a male predominance, which reaches the peak of incidence between the third and fifth decades of life and the first episode of sciatic pain was found at an average age of 37 year [11, 67].

Lumbar disc herniation has a favorable natural history. Most patients had improvement in pain and function during 6-8 weeks, but 10% had persistent pain and restrictions at work and leisure activities after one year. Magnetic resonance images have shown that disc herniations diminish in size over time and larger disc herniations tend to regress more with partial to complete resolution after 6 months in two thirds of people, most likely because of their higher water content [13, 20]. A positive correlation has been noted between regression of lumbar disc herniations and resolution of symptoms and regression is thought to occur as the herniated tissue dehydrates and immunological responses help to resorb the disc material [67].

The site of disc herniation appears to change with age. Although 95% of disc herniations occur at the L4/5 or L5/S1 level, with advancing age, there appears to be a relatively increased incidence of disc herniation at the L3/4 or even L2/3 level [21, 76].

2.1.1 Classification of disc herniation

The four stages to a herniated disc include:

First stage-A: Disc Degeneration – Age related changes in the shape of the annulus that causes it to bulge beyond its normal perimeter.

Second stage-B: Prolapse- The form or position of the disc changes with some slight impingement into the spinal canal and also called a protrusion. The posterior longitudinal ligament is still intact.

Third stage-C: Extrusion- The nucleus pulposus breaks through the wall of annulus fibrosus beyond the confines of the posterior longitudinal ligament, but remains within the disc.

Forth stage-D: Sequestration or Sequestered Disc- The nucleus pulposus breaks through the annulus fibrosus and extruded nucleus moved away from the prolapsed area in the spinal canal [24, 37].

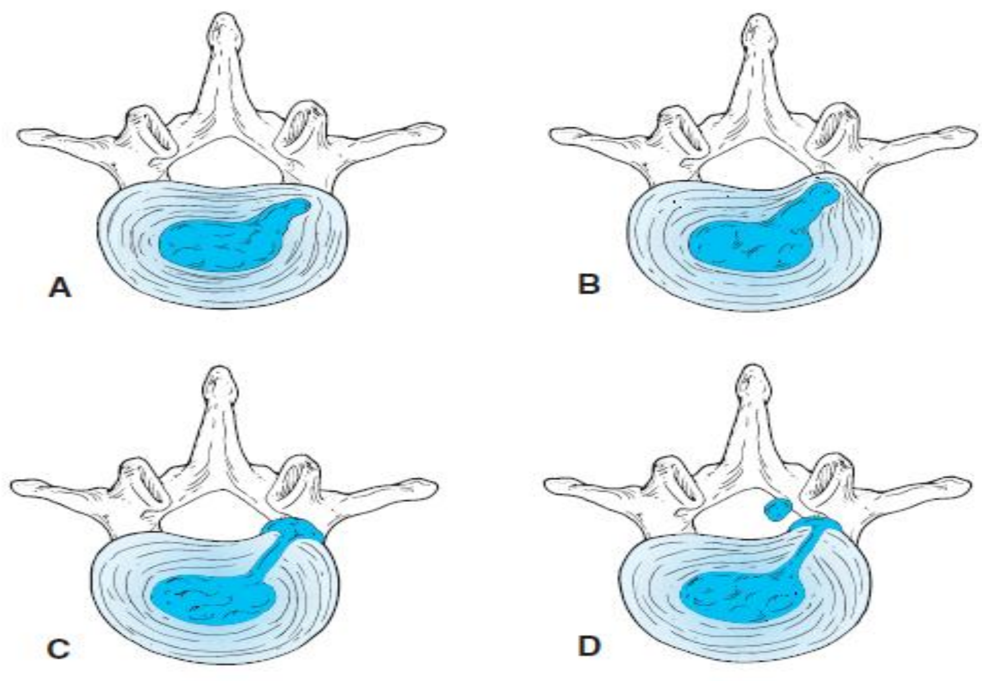

Figure 9. Classification of Lumbar disc herniation [37].

Disc herniation may be further specifically described with regard to a penetration of the posterior annulus and longitudinal ligament, respectively.

- Contained(include prolapsed disc)
- Non-contained(include extrusion and sequestration disc)

Displaced disc tissue which are completely covered by outer annular fibers or posterior longitudinal ligament and are not in direct contact with epidural tissue called contained disc. By contrast, displaced disc tissue in direct contact with epidural tissue called non-contained disc. This differentiation is of importance for minimally invasive surgical procedures such as percutaneous disc decompression [11, 24].

Additionally to previous classifications, displaced disc tissues may also be described by anatomical location of the disc herniation(Fig. 10): Central, posterolateral, lateral foraminal and lateral extraforaminal disc herniation.

Most disc herniations are located posterolaterally, where the posterior longitudinal ligament is the weakest laterally. Central herniations are the main localizations in the axial plane, whereas lateral disc herniations are less common (3–12%) [11].

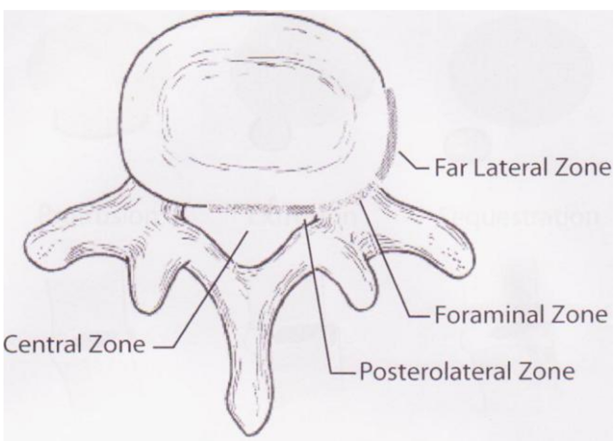

Figure 10. This axial view of a lumbar vertebra shows the anatomic zones where the disc can protrude [24].

2.2 The process of disc degeneration and disc herniation

2.2.1 Disc degeneration

Disc herniation has direct relationship to degeneration of the disc and to the severity of the degeneration [12, 55]. Disc degeneration comprises a wide spectrum of morphological and biochemical changes within the IVD or its entire structure [12]. The most common findings of disc degeneration are reduced proteoglycan content, diminished water content, reduced number of cells within the nucleus pulposus, disruption of the structure of the annulus, and increased amount of type I collagen [55].

The state of the IVD is dynamic over its lifetime [58]. With aging disc undergoes structural and chemical changes that in general are progressive and irreversible. Degenerative changes of the IVD become apparent as early as the second decade of life, although the tempo of progression varies considerably across individuals [18].

From the second decade of life the number of proteoglycan molecules reduces that follow occurrence of clefts, which lead to the formation of fibrous tissue later in life and nucleus pulposus becomes more fibrotic and less gel-like [58]. The annulus, which is composed of fibrous connective tissue at the third decade of life starts showing fissures. Later by the fourth decade, mismatch of cell death and cellular proliferation develops, leading to invasion of vasculature through the clefts and tears. The endplate has vasculature up to the third decade. It gets thinned with formation of clefts and fissures in the fourth decade and finally is replaced by fibrocartilage in the sixth decade [74].

Physiologically disc degeneration occurs with age, but “early degeneration” occurs quite frequently. Exposing of the IVD to the abnormal mechanical loads leads to metabolic changes in disc and as result to disc degeneration. When IVD exposed to abnormal chronic loads, disc cells respond by changing their extracellular environment. Changes in hydrostatic pressure, tensile strain or fluid loss can significantly influence the rate at which extracellular matrix macromolecules (proteoglycans, collagens), that lead to matrix component degradation. The consequent decrease in concentration of disc components results in loss of matrix integrity and failure of appropriate biomechanical response to loading, ultimately leading to morphological features of degeneration. This process alters disc structure that making them susceptible to rupture [18].

2.2.2 Functional Changes of the Disc due to Degeneration

From the second decade of life the nucleus begins to lose its strongly hydrophilic proteoglycans, that leads the disc becomes more solid and less adept at absorbing the axial loads and dispersing them to the surrounding structures. As a result of degenerative process, the nuclear becomes heterogeneous and absorbs axial loads in a nonuniform manner [58].

By using the technique of “stress profilometry”, it has been shown that the stress distribution (Fig. 11) in vitro in a normal, healthy disc under compression was very uniform and isotropic, whereas in a degenerated disc the stress distribution was nonuniform with sharp anisotropic peaks in the outer annulus [53]. Loading moves from the more central endplate to the peripheral regions including the annulus. This uneven distribution of forces across the endplate increases as the degenerative process progresses. Subsequently, increased compressive and shear forces are transmitted to the annulus, stressing its fibers. With continued strain on the annular fibers the result is fissuring and rupture of the annular complex. Stress concentration in the posterior annulus may predispose this region to disc prolapsed [66, 88]. Fissuring and concentration of stress permit the migration of nuclear fragments to the periphery of the disc and herald the herniation of disc material. This migration of nuclear material may occur in a gradual, or stepwise, fashion [58].

Degenerative discs have been shown to have a 25% decreased resistance to torsion. The reason is the loss of tension in the collapsed nucleus and annular tissue. Degeneration of the disc leads to increased laxity in motion in flexion-extension, axial rotation, and lateral bending. [58, 68] The high incidence of clinically evident disc disease at L4-L5 and L5-S1 may be related to this mechanics. These two areas carry the highest loads and tend to undergo the most motion in the sagittal plane.

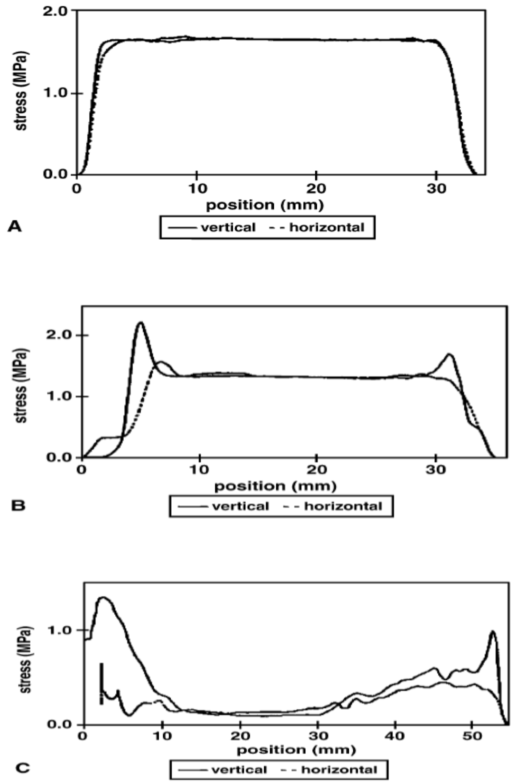

Figure 11. Stress profilometry across normal and degenerated intervertebral discs. The left and right side correspond to the posterior and anterior aspects of the disc, respectively. (A) A healthy cadaveric disc with uniform stress distribution. (B) A cadaveric degenerated disc with reduced stress magnitude across the nucleus pulposus and with stress concentrations in the annulus fibrosus. (C) Degenerated disc in vivo with reduced stress distribution across the nucleus pulposus and nonuniform anisotropic stress concentrations in the annulus fibrosus [53].

With loss of proteoglycan, the osmotic pressure of the disc fall and degenerative discs has lower water content than do normal age-matched discs. During loading discs lose height and fluid more rapidly. Such major changes in disc behavior have a strong influence on other spinal structures, and may affect their function and predispose them to injury [88].

The result of the rapid loss of disc height under load in degenerative discs can be abnormal load of the facet joints and eventually develop osteoarthritic changes. As a result of disc height loss reduce the tensional forces on the ligamentum flavum that may cause remodeling and thickening. With consequent loss of elasticity the ligament will tend to bulge into the spinal canal, leading to spinal stenosis [66].

2.2.3 Risk factors of disc degeneration

Traditionally it was believed that the strongest risk factors for the development of disc degeneration and subsequent herniation are lifestyle and environmental factors. Lifestyle factors such obesity, smoking and occupations factors which involves heavy manual labor (lifting, torsional loading and twisting), and exposure to vibration [58].

However in the last decade it was recognized that these factors play only minor role in the process in addition to genetic predisposition [74, 77]. Recent studies provided compelling evidence that, although environmental factors contribute to the incidence and progression of disc degeneration, the strongest predictors are the genetic factors which influence the size and shape of spinal structures, as well as the synthesis and breakdown of IVD structural components [12].

Studies which were performed on identical twins have shown that 70% of intervertebral disc degeneration can be attributed, in a statistical sense, to genetic inheritance rather than to the (mechanical) environment [20]. Patients who were diagnosed with a herniated lumbar disc before age 21 were 4 to 5 times more likely to have a positive family history for disc disease [14].

2.2.4 Disc prolapsed and the mechanism of nerve root compression

Flexion-extension and lateral bending of the spine generates alteration of steady-state pressure in the IVD. Flexion causes migration of the nucleus to the posterior aspect of the disc, whereas lateral bending causes the nucleus to be displaced contralateral to the side of bending as the tissue move from the area of high pressure to low [58]. Concurrently, the annulus during flexion-extension and lateral bending moves in the opposite side to nucleus pulposus and annulus is weaker dorsally than ventrally [68].

Axial loading of the spine in conjunction with flexion-extension and rotational moments combine to induce disc herniation. Torsional movements cause shifting of the spine's center of rotation to the posterolateral portion of the disc, and torsional loads have been proposed to induce lateral herniation [58].

Generally believed that disc prolapse occurs in three phases (Fig. 12) in lifting a weight. It usually occurs if the disc deteriorated as a result of repeated microtraumas and if the annulus fibres have started to degenerate. Disc prolapse usually occurs during lifting of a weight with flexion of the trunk forward [35] with followed axial rotation [78].

During the first phase trunk flexion (A) flattens the discs anteriorly and opens out the intervertebral space posteriorly. During the second phase (B), as soon as the weight is lifted, the increased axial compression force crushes the whole disc and violently drives the nuclear substance posteriorly until it reaches the deep surface of the posterior longitudinal ligament. During the third phase (C) with the trunk nearly straight, the path taken by the herniating mass is closed by the pressure of the vertebral plateaus and the hernia remains trapped under the posterior longitudinal ligament. As a result of repeated trauma, the hernia grows in size and protrudes more and more into the vertebral canal. At this point it comes into contact with a nerve root [35].

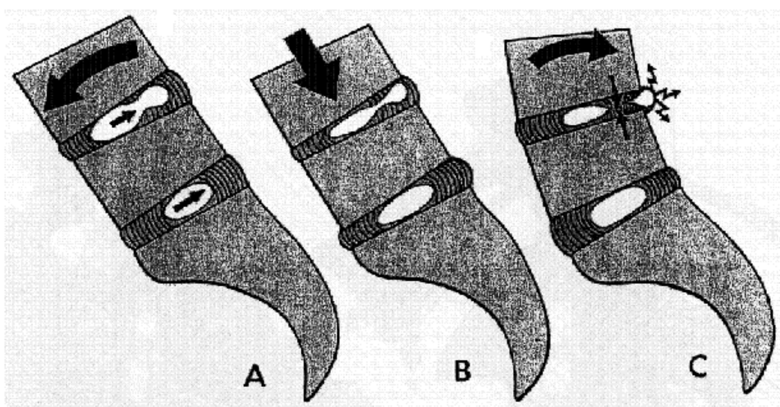

Figure 12. Mechanism of disc prolapsed [35].

2.2.5 Clinical feature of disc herniation

The lumbar intervertebral disc plays a central role in the development of low back-related leg pain and radiculopathy [79]. Pain originated at the level of the disc produced by two mechanism: Mechanical compression and chemical irritation of the nerve root [90] and can be divided into categories according to the pathomechanism involved [79].

Mechanical compression mechanisms are based on the direct mechanical compression of the protruded nucleus pulposus on the nerve root that lead to impaired intraradicular blood flow, increased endoneural fluid pressure and nerve fibers deformation. This combination of increased endoneural fluid pressure and decreased blood flow may result in neuronal ischemia leading to breakdown of axonal myelin sheaths and alteration of the blood-nerve barrier. Such structural nerve damage may be the cause of sensory and motor dysfunction and radiating pain [79].

Chemical irritation mechanisms are based on the direct biochemical effects of nucleus pulposus components on nerve fiber structure that lead to inflammatory reactions of the nerve root and [41]. Biochemical irritants of nuclear tissue from internal disc disruption, fissure formation, nucleus pulposus prolapsed and sequestration include an activation of the pro-inflammatory cytokines such as interleukin 6 (IL-6), TNF-alpha and nitric oxide (NO) that associated with inflammation [46, 79]. The pro-inflamatory cytokines excite nociceptors either directly or indirectly via prostaglandin synthesis and may be the cause of neurological signs and symptoms, especially neurogenic pain [47, 79].

Pain that originated at the level of the disc can be divided to categories:

- Discogenic pain (Typically manifested as axial back pain caused by mechanical loading of a pathologically degenerated disc [58] or degenerative changes that associated with internal disc disruption, commonly lead to fissures in the annulus, which allow inflammatory mediators to disperse through the disc and contact the innervated outer third of the annulus. These chemicals may cause excitation of nociceptive afferents and thereby pain [79]). Most patients present with back pain as the earliest symptoms of the degenerative disc disease.

- Referred pain (Results from activation of nociceptive free nerve endings (nociceptors) in somatic or visceral tissue). Pain begins in the lower back and is referred to the sacroiliac region and buttocks. In some cases pain can be referred to the posterior thigh [90].

- Radicular pain (Typically manifested as leg pain caused by process originating at the level of the root and results from irritation of axons of a spinal nerve or neurons in the dorsal root ganglion)[58].

Schafer divided the low back-related pain into four subgroups according to predominant pathomechanism involved.

- The first subgroup features central sensitization with mainly positive symptoms such as paraesthesias, dysaesthesias, hyperalgesia.

- The second subgroup involves denervation with significant axonal damage showing predominantly negative sensory symptoms and possibly motor loss.

- The third subgroup involves peripheral nerve sensitization with enhanced nerve trunk mechanosensitization. If the disorder is severe enough, the patient may present with an antalgic posture to protect mechanosensitive nerve tissue.

- The fourth subgroup features somatic referred pain from musculoskeletal structures, such as the intervertebral disc or facet joints [79].

Between four separated groups had been made differentiation, but, in reality, there may be considerable overlap between these four groups. Peripheral sensitization of nerve tissue can trigger central sensitization, and inflammatory products released during denervation may also alter the properties of intact nerve fibres. Mixed pathology can be possible, as many radicular disorders undoubtedly are a mixture of nociceptive and neuropathic pain [79].

2.3 Clinical evaluation of lumbar disc herniation

2.3.1 History and Physical examination

The history and well-structured physical examination are essential components in assessment and diagnosis of lumbar disc herniation [80]. They are critical in the differentiation of patients to reaching an accurate diagnosis [80] and very important part in the initial consultation when dealing with suspected disc herniation patients [38].

The history of the suspected disc herniation patients includes both the present and past history of the pain and symptoms [38] and important notes in ruling out serious pathological conditions such cauda equina syndrome that need emergency surgical intervention [29].

The physical examination complements the history and is essential in determining the main disturbance factors that affect lumbar disc herniation's patients. The physical examination consists: Gait and posture observation, Active and passive movements, Muscle function tests, Neurologic tests (e.g. motor weakness, sensation and deep tendon reflexes), and Special tests for nerve root lesion [38, 90].

2.3.2 Special tests for clinical examination of lumbar disc herniation

Straight leg raising test (SLRT)

The Straight Leg Raising test (Lasegue Test) (Fig. 13) is widely used as 1st of the primary diagnostic physical examination tests, in patients who have low back and leg pain [42, 48].

The patient lies supine, and the examiner gradually flexes the thigh at the hip, while the leg is held in extension at the knee by the examiner. The test is positive if the maneuver elicits shooting pain radiating down the posterior thigh along the course of the sciatic nerve, and often into the lower leg, with elevations of 70° or less. Provocation of low back pain alone is not highly suggestive of nerve root impingement. Straight leg-raising stretches the L5 and S1 nerve roots 2 mm to 6 mm, but it puts little tension on the more proximal (L2, L3, and L4) nerve roots. An abnormal straight-leg-raising test, therefore, suggests a lesion of either the L5 or the S1 nerve root [48].

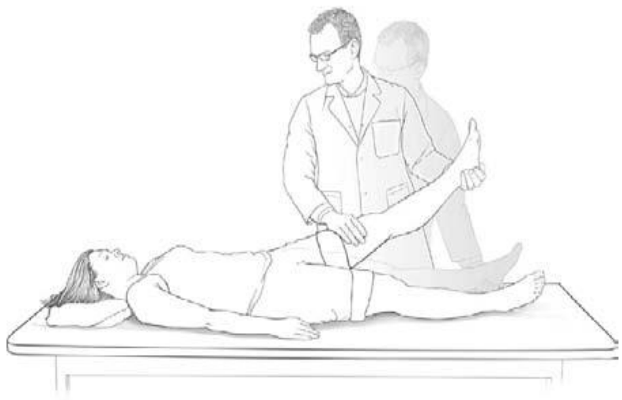

Figure 13. The straight leg raising test [10].

Cross-leg SLRT

Crossed SLR test in which pain in the affected lower extremity is brought out by SLR of the contralateral asymptomatic limb is highly suggestive of nerve root compression by a herniated or possibly extruded lumbar disk. These tests are “more positive” if they bring out the patient’s usual pain and if the pain is provoked with lower elevation of the lower limb [10].

Slump test

The Slump test is a progressive series of maneuvers designed to place the sciatic nerve roots under increasing tension. The patient begins the Slump test sitting on the side of the examination table with the back straight, looking straight ahead. The patient is then encouraged to slump, allowing the thoracic and lumbar spines to collapse into flexion while still looking straight ahead. The next step is to fully flex the cervical spine. The patient is then instructed to extend the knee and dorsiflexes the foot on the same side. At each step in the procedure, the patient informs the examiner what is being felt and whether radicular pain is produced [10, 48].

Many normal individuals feel tightness in the lower back and the thigh with this series of maneuvers. Reproduction of familiar is highly suggestive of sciatic nerve root tension.

Subsequent extension of the neck relaxes the spinal cord and may thus relieve nerve tension [48].

Reverse SLR

Reverse SLR is performed with the patient prone. The knee on one side is passively flexed until pain appears on the anterior aspect of the thigh. Provocation of the patient's same-sided limb pain is highly suggestive of impingement of the L2, L3, or L4 nerve roots. These three roots contribute to the femoral nerve and are stretched by the reverse SLR maneuver [10].

2.3.3 Clinical findings of radicular syndromes

<u>L- 4 root syndrome:</u>

- Pain radiates over the ventral aspect of the thigh to the knee and can radiate further on the anteromedial aspect of the leg down to the medial ankle and to the medial aspect of the big toe.
- Weakness of the muscles: Quadriceps and of the Hip flexors and even of the adductors
- Decreased Patellar reflex
- Hypesthesia can be present mainly on the anterior aspect of the thigh
- Positive reversed SLR test
- Walking stairs difficulty [42].

<u>L-5 root syndrome:</u>

- Pain radiates on the lateral aspect of the thigh and middle leg to the lateral ankle and over the instep to the big toe and to the second and third toes
- Weakness of the muscles: Extensor hallucis longus, Extensor digitorum longus, Tibialis anterior, Extensor digitorum brevis
- TrP in muscle Piriformis
- Restricted skin stretch b/w first and second, second and third toes

- Hypesthesia can be present on the lateral aspect of the thigh and middle leg as far as the lateral malleolous and then over the instep to the big toe
- SLRT test (Laseque sign) positive
- Difficulty walking on heels [42].

S-1 root syndrome:

- Pain radiates on the posterolateral aspect of the thigh and middle leg, towards the heel and over the lateral aspect of the foot to the fourth and fifth toes
- Weakness of the muscles: Gluteal muscles, Triceps surae, Flexors of the toes
- TrP in muscle Iliacus
- Restricted skin stretch between third and fourth, fourth and fifth toes
- Decreased Achilles tendon reflex
- Hypesthesia can be present on the posterolateral aspect of the thigh and middle leg, towards the heel and over the lateral aspect of the foot to the fourth and fifth toes [42].

2.3.4 Imaging modalities in diagnosis of lumbar disc herniation

Imaging modalities evaluated to detect lumbar disc herniation includes: Computed tomography (CT) scan, Magnetic resonance imaging (MRI), and CT myelography [11].

Standard X-rays are not helpful in the diagnosis of lumbar disc herniation, and most useful in excluding the pathological conditions which may have the similar symptoms as disc herniation [90].

In the diagnosis of disc herniation and in determining the exact level of the herniation MRI (Fig. 14) preferred over CT for better accuracy. MRI has better visualization of spine tissue and nerve roots. Additional advantage of MRI comparing to CT is in postoperative differentiation of scar from recurrent herniation [29].

CT myelography rarely indicated, although can exactly visualize spinal nerve roots. This method useful for patients with contraindications to MRI (cardiac pacemakers) or when standard CT has difficulty to define and differentiate the anatomic correlates of the clinical presentation [80].

In spinal disorders, electromyography (EMG) is the method of choice for the identification of damage within the peripheral motor nerve fibers (highest sensitivity). However, the delay between the time of the actual damage and the first signs of denervation (acute denervation potentials occur after a mean of 21 days) must be considered. Also the activation pattern (complete or reduced interference) assessed during voluntary activation (here the patient needs to cooperate and perform a voluntary activation) can be applied as soon as the very first few days after a lesion to disclose a pathological innervation. The performance of EMG in several muscles allows the specific localization of the nerve damage (somatotopic localization of a lesion) to be indicated and for the differentiation of acute, subacute and chronic axonal damage (denervation). The EMG has a high specificity and will rarely be abnormal in asymptomatic individuals but is usually not performed until at least 3 weeks after the symptoms begin [11].

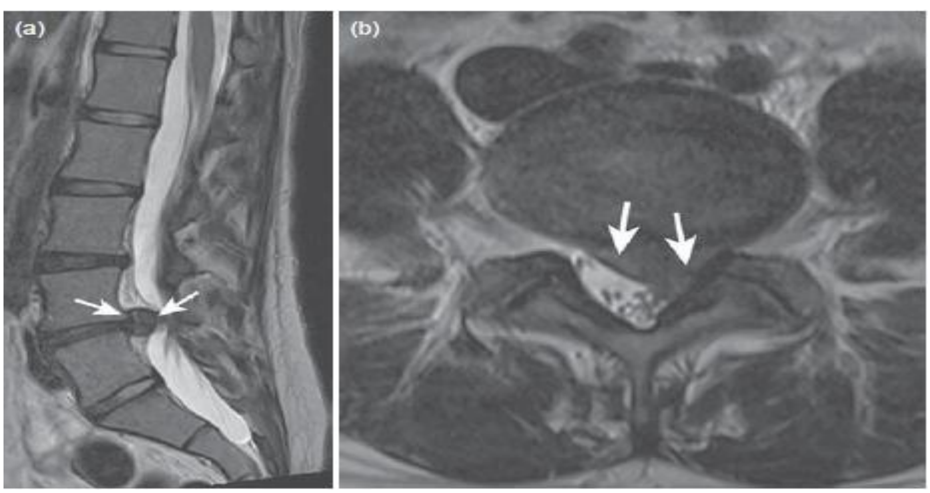

Figure 14. MRI in acute lumbar radiculopathy. (a) Sagittal and (b) axial T2-weighted images show a very large left L4–L5 disk extrusion compressing the thecal sac [10].

3. Treatment options of lumbar disc herniation

3.1 Conservative treatment

A majority of the patients suffering from lumbar disc herniation experience a positive natural history and respond well to conservative treatment. For 90 percent of patients with lumbar disc herniation, acute sciatica starts to improve within six weeks of conservative care [26].

Conservative treatment for lumbar disc herniation are primarily aimed in reducing of the pain, regaining of activities of daily living and reversal of neurologic function [11]. The most common and available conservative methods in management of lumbar disc herniation include: oral medications, therapeutic injections, physiotherapy, traction and manipulation [96].

It is generally accepted that patients should undergo conservative treatment for at least 6 - 12 weeks before considering surgical treatment [26].

3.2 Conservative treatment modalities

3.2.1 Oral Medication

Analgesic and adjuvant pain drugs are often prescribed for patients with lumbar disc herniation to relief pain, reduce inflammation and muscle spasm. Patients with a clinical diagnosis of sciatica are about five times more likely to take drugs than those with low back pain only [61]. Commonly prescribed drugs for the primarily care for treatment of lumbar disc herniation include non-steroidal anti-inflammatory drugs (NSAIDs), skeletal muscle relaxants, opioid analgesics, benzodiazepines, systemic corticosteroids, antidepressants, and anticonvulsants [96]. While guidelines provide clear and generally consistent recommendations for the prescription of drugs for non-specific low back pain, this is not the case for sciatica [61]. Among the various medications which available in treatment management to reduce pain, pharmacological strategy has to select particular medications considering the following indications, contraindications, goals of treatment, analgesia, reduction of inflammation and muscle spasm [96].

3.2.2 Therapeutic Injection

Epidural corticosteroid injections have been widely used in clinical practice for many years [91]. In treatment of lumbar disc herniation there are available several therapeutic injection procedures to reduce pain and improve the patient's functional status.

Pain pathogenesis in cases with nerve root compromise is caused not only by a mechanical compression but also by a chemical irritation due to proinflammatory cytokines. The rationale for epidural injections aims to diminish the inflammatory component of a neural compromise [11].

Epidural steroid injection (ESI) is a generic term used to indicate various types of injections that attempt to introduce one or more medications into the epidural space. Not all ESIs involve corticosteroids. It can involve also local analgesic.

There are three main subtypes of ESIs that are named according to the method used to introduce therapeutic agents into the epidural space:

- Caudal ESI (CESI)
- Interlaminar(interspinous) ESI (ILESI)
- Transforaminal ESI (TESI)

The CESI and IESI approach are the most commonly used as they can generally be performed without radioscopic or CT control. This technique is easier to perform, with a low risk of complication [22].

The TESI is always performed under image radioscopic or CT control, allowing for a direct application of the anti-inflammatory agent to the target nerve root. TESI is also termed selective nerve root injection or selective nerve root block [11].

The objective of a therapeutic injections are not to cure the patient by interfering with pathogenetic factors that are responsible for sciatica but rather to provide temporary relief from peak pain during the time required for spontaneous resolution of radiculopathy [11].

In contrast to the selective nerve root blocks, epidural steroid injections have some disadvantages. The pharmacological agents have to diffuse to the site of inflammation and there is no guarantee that they do it. In cases with multilevel involvement or non-specific leg pain the epidural route has some advantages compared to selective nerve root blocks [22].

3.2.3 Bed rest

The rationale for bed rest relates to the reduction in both mechanical pain and intradiscal pressure in the supine position [62]. For many years was considered that patients with acute sciatica had to have long period of bed rest, however in the recent years the optimal duration of bed rest remains debatable. In the last years long period of bed rest not recommended and such advice has been found to have a harmful effect because excessive bed rest can result in physical deconditioning [96].

3.2.4 Physiotherapy

Physiotherapy in the acute phases focuses on a pain reducing positioning [11]. After the acute phases therapeutic exercises which strengthen the back muscles and improve health status of the patients represent a cornerstone of conservative treatment. Exercise that improves trunk strength and balance and does not exacerbate leg pain appears to be preferable.

Physiotherapy techniques include:
"Back Pain Functional Training" that provide instruction how to move and positions that will help ease pain and discomfort. This technique includes patient education of pain mechanism, posture and positioning for pain relief at home, and avoidance of aggravating factors.
The main types of therapeutic exercise relevant to sciatica include:

- General physical activity (e.g., advice to remain active)
- Flexibility (e.g., self-stretching, therapist assisted stretching, neural mobilization with patient tolerance)
- McKenzie back exercise.

- Therapeutic exercise that maintain stability in the lumbar spine. This type of exercise approach has been termed lumbar stabilization, core stabilization, or segmental stabilization. This approach is generally aimed at improving the neuromuscular control, strength, and endurance of muscles central to maintaining dynamic and static spinal and trunk stability [22].

3.2.5 Traction

In the previous year's lumbar traction therapy was a common treatment of lumbar disc herniation. It considered that traction has effects such as reducing pressure on disc by enabling vertebral separation, reducing pressure on the nerve root by enabling expansion of neural foramen, enabling to stop edema and inflammation, helping the disc to be repressed to back by creating tension on ligamentous structures besides having aspects such as acting as anti-spasmodic in paravertebral muscle spasm, creating intra-articular expansion and recovery of spinal incline [15].

Lumbar traction can be applied in a variety of ways, with the patient in a range of postures. Different traction techniques, manual traction (traction exerted by the therapist, using the patient's head, arms, or legs) and motorized traction (traction exerted by a motorized pulley) are most often used, whereas inverted suspension (traction exerted by gravitational forces, through the body weight of the patient) and bed-rest traction (traction is exerted by a pulley and weights) [43].

Traction therapy is a broad term used to refer to any method of separating the lumbar vertebrae along the inferosuperior axis of the spine by using mechanical force. The most common types of traction therapy are based on the duration of its application, which may be intermittent (alternating traction and relaxation with cycles of up to a few minutes), sustained (20 to 60 minutes) or continuous (hours to days) [22].

There is no consensus on the choice or indications of the various forms of traction therapy, but it appears that intermittent motorized traction with the patient in the Fowler's position (supine with the hips and knees flexed, and the lower legs supported on a stool) is most frequently used [43].

3.2.6 Manipulation

Manipulation in treatment of lumbar disc herniation varies widely among chiropractors and osteopathic physicians. The rationale for manipulation includes reduction of a bulging disc, correction of disc displacement, release of adhesive fibrosis surrounding prolapsed discs or facet joints and entrapped synovial folds or plicae, inhibition of nociceptive impulses, relaxation of hypertonic muscles, and unbuckling displaced motion segments [50].

The techniques are equally divergent, with a force range encompassing gentle repetitive range of motion movements in an active assisted fashion to high velocity flexion and rotation thrust motion produced by the manipulator on a totally passive patient [82].

3.3 Surgical treatments

The surgical treatment of lumbar disc herniation is estimated to be necessary in 10 percent from all lumbar disc herniations cases [26]. Surgical intervention for lumbar disc herniation focuses on removal of disc herniation and eventually part of the disc with the purpose of eliminating the cause of corresponding symptoms [70]. Surgical treatment should be considered as the final phase of treatment when all other forms of conservative treatment have not been effective in reducing of the pain or restoring normal physiological function [26].

3.3.1 Surgery indication of lumbar disc herniation

The absolute indication for surgery is a progressive neurologic deficit, such as cauda equina syndrome or severe paresis [26].

Relative indications for surgery are:

- Severe sciatica with large herniation non-responsive to pharmacological treatment.
- Failure of conservative care and persistent radicular leg pain over 6-8 weeks with or without nerve root affection.
- Persistent mild sensorimotor deficit more than 6 weeks [11, 70].

3.3.2 Surgery procedures

The goal of disc hernaition surgery is to decompress the affected nerve root by removing the herniated disc tissue [11, 70]. There are varieties of decompression surgery used by orthopedic and neurologic surgeon, which are usually named according to the structure that is surgically removed.

The two main types of decompression surgery are discectomy and laminectomy. Discectomy implies surgical excision of an intervertebral disc, whereas laminectomy involves removal of the lamina. Either procedure may involve partial or complete removal of the targeted structures. The conventional open discectomy involves use of a standard surgical incision to obtain adequate visualization and illumination, then frequently performance of a hemilaminotomy to relieve pressure on the nerve roots and visualize the protruded disc, followed by a discectomy to remove the herniated nuclear disc material [32].

With the introduction of the operating microscopic and microsurgical techniques, the standard open discectomy was refined into the microdiscectomy. The technique of microsurgical discectomy was introduced by Caspar and Williams in the late 1970s. The use of the operating microscope to expose the compressed nerve root has several theoretical advantages. The most important reason is the maintenance of a three-dimensional view in the depth of a spinal wound. Furthermore, microdiscectomy exhibits the advantage of stronger illumination and magnification of the operative field and a smaller approach, which may result in a more rapid recovery [83].

Microdiscectomy(Fig. 15) is the gold standard operative treatment for lumbar disc herniation and performed via a posterior approach either in the prone (on a frame or chest role), knee chest or lateral portion. The incision is relatively small, usually about two-three centimeters. To reveal the nerve and relieve pressure on it, the surgeon removes a small part of the facet joint, the bone that lies directly over the nerve root. The portion of the disc that is compressing the nerve is removed, along with other loose fragments. The surgery normally takes one or two hours. With a microdiscectomy, the tissue and muscle damage is minimal, so scarring is reduced and recovery time is much quicker than traditional open back surgery [51]. In an EMG study, it was shown that the use of a microscope resulted in less irritation of the nerve root [11].

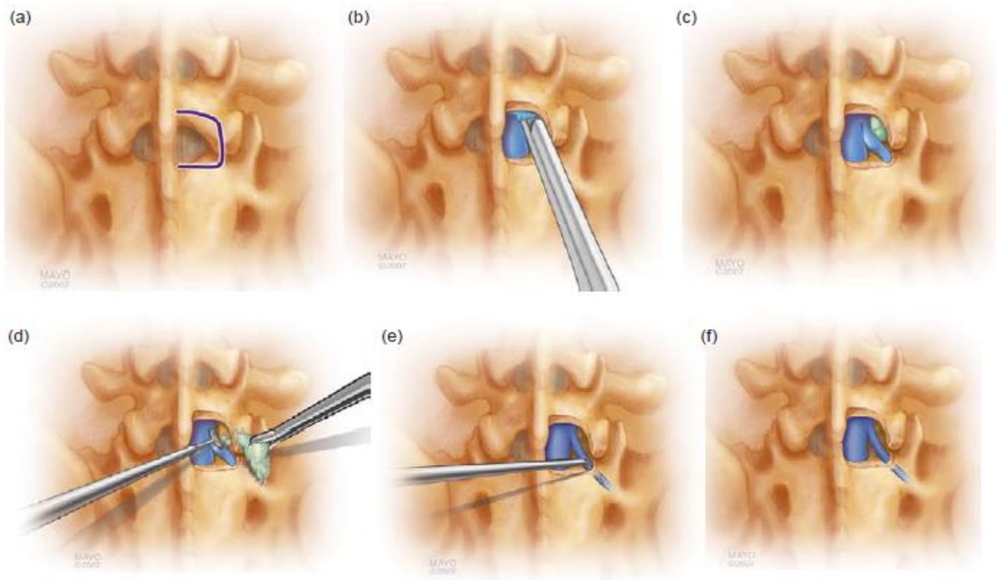

Figure15. a-e. Steps involved in lumbar microdiscectomy. (a) Exposure of lamina and facet joint with outline of the anticipated partial hemilaminectomy and medial facetectomy. (b) Removal of laminar bone and ligament flavum with the Kerrison punch. (c) Extruded disk is exposed. Note medial and posterior displacement of the traversing nerve root. (d) Removal of disk fragment, while gently retracting the traversing nerve root and common dural sac. (e) Probing the foramen of the traversing nerve root to check for additional disk fragments. (f) Appearance of surgical site after discectomy [10].

In recent years there has been an effort across all disciplines of surgery to minimize the incisions in order to achieve less damage to healthy tissue, permitting faster recovery, less hospital stay (and therefore reduced cost). In 1993, Mayer and Brock, and in 1997, Smith and Foley described endoscopic discectomy techniques. These techniques, considered minimally invasive, used tubular retractors to approach the intervertebral space allowing less soft tissue manipulation [27].

Minimally invasive microdiscectomy was developed to improve on traditional microdiscectomy, and leads to different surgerical approach. The microdiscectomy is traditionally done by mobilizing the muscles laterally off the spinous process and lamina using a unilateral retractor. A minimally invasive microdiscectomy involves dilating the paraspinous muscles and using tubular retractors without stripping the muscles off the spinous processes. Although these advanced have become popularized, little scientific evidence has been reported to demonstrate that outcomes with minimally invasive discectomy are superior to traditional microdiscectomy [83].

3.3.4 Surgical complications

- Wrong-site surgery (operation at the wrong spinal level).
- Dural tear and Cerebrospinal fluid leaks (risk is greater with minimally invasive techniques.
- Neurovascular injury (excessive manipulation or retraction for better expose the disc fragment is the main reason).
- Persistent radicular complaints- Microdiscectomy is associated with a 10% to 15% failure rate. Persistent radicular symptoms may present as either pain or weakness, which may be caused by insufficient neural decompression, traumatization of the nerve root, and perineural scarring.
- Disc reherniation- Reccurent herniation after disc excision has been reported in 5% to 11% of patients.
- Iatrogenic spinal instability- Radical discectomy may compromise the stabilizing function of the disc and increase the severity of low back pain. Aggressive facetectomy or violation of the pars interarticularies can result in intersegmental destabilization [10, 51, 83].

4. Objectives and research method

The diploma thesis is written in the form of literature review.

Aim of the thesis:

The main purpose of this thesis is to assess the efficacy of main types of conservative and surgery treatments of the lumbar disc herniation and factors that influence clinical outcomes in patients undergoing this treatment.

Investigative questions:

1. What kind of conservative treatments scientifically proven advantages in the treatment of lumbar disc herniation?

2. What kind of surgical interventions with focus on the three surgical techniques (open discectomy, microdiscectomy and micro-endoscopic discectomy) scientifically proven advantages in the treatment of lumbar disc herniation?

3. What are the results of conservative and surgery treatments of lumbar disc herniation in period up to 2 years in removing of initial symptoms of disc herniation?

Hypothesis:

Surgical intervention like microdiscectomy is the most appropriate treatment option than prolonged conservative care in patients with lumbar disc herniation who doesn't have improvement in symptoms after 6-12 weeks of conservative care.

Methodology

Criteria for considering studies for this review:

<u>Types of studies:</u>

Clinical trials, systematic reviews, case reports and pilot studies published between 1992-2013 years and performed in Europe, Northern America and Far East, originally in English language or translated to English were included.

<u>Types of participants:</u>

Patients b/w 18-70 years old with an acute (less than 6 weeks), subacute (6-12 weeks) or chronic (12 weeks or more) symptoms of lumbar disc herniation as primary diagnosis were included.

<u>Types of interventions:</u>

All types of conservative treatment such as oral medication (e.g. NSAIDs, corticosteroidsids, and muscle relaxants), different types of injections, physical therapy, spinal manipulation, bed rest, traction and different types of surgery treatment such as open discectomy, microdiscectomy, and micro-endoscopic discectomy were included.

Search strategy for identification of studies:

Studies were collected from following database: PubMed, Cochrane library and ScienceDirect database to develop strategy of searching with following keywords listed below to identify relevant references of treatment information about disc herniation with main concern of treatments benefits and differentiations.

Keywords: Lumbar disc herniation, conservative treatment, surgery treatment, microdiscectomy, sciatica, radiculopathy. Different combinations of these words were used in strategy of searching.

During the work on this thesis were used books and periodicals published in English language, which cover topics and issues raised in this thesis and were used in theoretical part of the thesis. Literature search was performed through electronic database using the keywords: Lumbar disc herniation, sciatica, radiculopathy.

5. Results

While working on diploma thesis were used systematic reviews, randomized controlled trials and cohort studies for researching different kinds of lumbar disc herniation treatments. The results of researching were tabled by four main parameters:

Pain relieve, Overall improvement, Functional improvement and Quality of the life to present the results of different treatments of lumbar disc herniations.

Four main parameters include the follow types of outcome measures that were used in overviewed studies:

Pain- Back and leg pain intensity was assessed by visual analogue scales (VAS) [22].

Overall improvement- Was assessed by subjective improvements of symptoms and satisfaction from treatment.

Functional improvement- Was assessed by Roland Morris Disability Scale, Oswestry Disability Index and degrees of straight leg raising [22].

Quality of life- Was assessed by Medical Outcomes Study Short Form Health Survey 36 (SF-36) [22].

The treatment outcomes were assessed at short-term follow-up (less than 6 weeks after onset of the treatment), at intermediate follow-up (between 6 weeks and 6 month of the onset treatment) and at long-term follow-up (6 month or more after onset of treatment).

Table 1. Results reported in systematic reviews regarding to conservative treatment of lumbar disc herniation

Author Year	Participants	Treatment	Included trials	Outcome and Follow-up
Rafael Zambelli Pinto et al. (2012) [61]	Patients with acute, subacute and chronic symptoms	NSAIDs vs placebo	4 RCT	Small and non-significant effect in favour of NSAIDs in pain relieve (back and leg) in the immediate and short term.
		Corticosteroids vs placebo	3 RCT	Non-significant effect in favour of corticosteroids in pain relieve (back and leg) in the immediate term. Significant effect in favour of corticosteroids in the short term in pain relieve (back and leg).
.		Anticonvulsants vs placebo	3 RCT	No evidence effect in favuor of anticonvulsants in pain relieve (back and leg) in the immediate and short term.
		Opioid analgesics Antidepressants combination of both vs placebo	1 RCT	No evidence effect in favour of opioid, antidepressants and combination of both in pain relieve(back and leg) in the immediate and short term.
Vroomen et al. (2000) [94]	Patients with acute, subacute and chronic symptoms	NSAIDs vs placebo	3 RCT	No evidence effect in favour of NSAIDs for pain relieve after 5-30 days of follow-up
Luijsterburg et al. (2007) [45]	Patients with acute, subacute and chronic symptoms	NSAIDs vs placebo	1 RCT	No evidence effect in favour of NSAIDs for pain relieve in short term.
		Muscle relaxants vs placebo	1RCT	No evidence effect in favour of muscle relaxants for pain relieve in short term.
		ESI vs placebo	9 RCT	Conflicting evidence regarding to pain relieve and overall improvement in favour of ESI group at short term. Non-significant effect in favour of ESI group regarding to pain relieve and overall improvement at long term. For functional improvement non-significant effect in long and short term.
		ESI or IMI vs NSAIDs or Anesthetic	4 RCT	Conflicting evidence of benefit ESI over NSAIDs and Anesthetic regarding pain relieve in short term. Non-significant effect in favour of ESI for pain relieve in long term.

		Physiotherapy vs other conservative treatment	2 RCT	No difference in favour of physiotherapy over other conservative treatment regarding to pain relieve, overall improvement in short term
		Traction vs Inactive/sham traction	4 RCT	No difference in favour of traction over the inactive/shame traction regarding to pain relieve and functional improvement in short term
		Tracttion vs conservative treatment	5 RCT	No difference in favour of traction over conservative care regarding pain relieve and overall improvement in short term
Mclain et al. (2004) [49]	Patients with acute, subcute and chronic symptoms	Epidural injections of corticosteroids vs placebo	7 RCT	Conflicting evidence in favour of ESI for pain relieve(back, leg) and overall improvement in short term. Non-significant effect for pain relieve (back, leg) and overall improvement in long time.

*RCT- Randomized controlled trial, *ESI- Epidural corticosteroid imjection, *NSAIDs- Non-steroidal anti-inflammatory drugs, *IMI- Intra muscular injection.

Table 2. Results reported in randomized controlled studies regarding to conservative treatment of lumbar disc herniation

Author Year	Participants	Treatment	Outcome and Follow-up
Arden et al. (2005) [2]	228 patients with subacute and chronic complaints	ESI, N=120 vs placebo, N=108	Significant effect ESI group demonsrate at 3 weeks in functional improvement. Non-significant improvement of ESI group for pain relieve (back and leg), functional and overall improvement at 6-52 weeks.
Buchner et al. (2000) [16]	36 patients with acute, subacute and chronic complaints	ESI, N=17 vs no injection, N=19	Significant effect ESI group demonstrate at 2 weeks for relieve of the pain. Non-significant effect ESI group demonstrate at 6 week, 6 month for pain relieve and functional improvement.
Valat et al. (2003) [92]	85 patients with acute, subacute and chronic complaints	ESI, N=43 vs placebo, N=42	Significant effect ESI group demonstrate for relieve of the pain and functional improvement at 20 day. Non-significant effect of ESI group for relieve of the pain, overall and functional improvement at 35 day.

Thomas et al. (2003) [87]	31 patients with acute and sub-acute complaints	TESI with RC, N=15 vs ESI without RC, N= 16	Significant effect in favour of TESI group for functional improvement at 6 day Significant effect in favour of TESI group for relieve of pain at 30 day Significant effect in favour of TESI group for relieve of the pain and overall improvement at 6 month
Vroomen et al. (1999) [93]	183 patients with acute complaints	Bed rest, N=92 vs Watchful- waiting N=91	No difference in favour of bed rest over the watchful-waiting for pain relieve and functional improvement at 2 and 12 weeks
Hofstee et al. (2002) [31]	250 patients with acute complaints	Bed rest, N=84 vs Continuation of ADL N=83 vs Physiotherapy N=83	No difference in favour of bed rest over continuation of ADL for pain relieve, overall and funional improvement at 1, 2 and 6 month. Non-significant effect in favour of Physiotherapy over continuation of ADL for pain relieve, overall and functional improvement at 1,2 and 6 month
Luijsterburg et al. (2008) [44]	135 patients with acute complaints	Physiotherapy plus General practitioners care, N=67 vs General practitioners alone, N=68	No difference regarding to relieve of pain, functional improvement and quality of life b/w two groups at 3,6, 12 and 52 weeks. Significant effect in favour of physio-therapy plus general practitioners regarding to overall improvement at 52 week
Rattanatharn et al. (2004) [65]	120 patients with acute complaints	Traction N=60 vs. inactive/shame traction N=60	No differences regarding to functional and overall improvement at 4 weeks

*ESI- Epidural corticosteroid imjection, *TESI- Transforaminal epidural steroid injection, *RC-Radiologic control.

Table 3. Results reported in randomized controlled studies that compare surgical versus conservative treatment of lumbar disc herniation.

Author Year	Participants	Treatment	Outcome and Follow-up
Osterman et al. (2006) [57]	Patients with subacute symptoms	Surgery group, N=28 vs conservative care, N=28	Non-significant differences regarding to functional improvement b/w two groups at 2 years . Significant effect in favour of surgery group regarding to pain relieve (leg) and overall improvement only at 6 weeks.

Weinstein et al. (2006) [97]	Patients with subacute and chronic symptoms	Surgery group, N=232 vs conservative care, N=240	Non-significant differences regarding to overall and functional improvement b/w two groups at 3 month, 1 and 2 years. Significant effect in favour of surgery group regarding to pain relieve at 3 month, 1 and 2 years. **Restricted criteria**: adherence to assigned treatment was limited
Peul et al. (2008) [64]	Patients with subacute symptoms	Surgery group, N=141 vs conservative care, N=142	Significant effect in favour of surgery group regarding to pain relieve(leg) and functionall improvement at 12 weeks.

Table 4. Results reported in cohort studies that compare conservative versus surgical treatment of lumbar disc herniation.

Author Year	Participants	Treatment	Outcome and Follow-up
Atlas et al. (1996) [4]	Patients with chronic symptoms	Surgical group, N=217 vs conservative, N=183	Significant effect in favour of surgical group regarding to pain relieve, functional and overall improvement at 1 year.
(2001) [5]			Significant effect in favour of surgical group regarding to pain relieve and overall improvement at 5 years.
(2006) [6]			Significant effect in favour of surgical group regarding to pain relieve(back) and functional improvement at 10 years.
Weinstein et al. (2006) [98]	Patients with subacute and chronic symptoms	Surgery group, N=528 vs conservative care, N=191	Significant effect in favour of surgery group regarding to pain relieve, overall and functional improvement at 3 month.
(2008) [99]			Significant effect in favour of surgery group regarding to pain relieve, overall and functional improvement at 4 year.

Table 5. Results reported in randomized controlled studies comparing different surgical techniques in treatment of lumbar disc herniation.

Author Year	Participants	Treatment	Outcome and Follow-up
Teli et al. (2010) [82]	Patients with subacute and chronic symptoms	Microdiscectomy, N=72 vs micro-endoscopic, N=72 and open discectomy, N=70	No differences regarding to pain relieve, quality of life and functional improvement b/w three groups at 6,12,24 month. Significant differences in complications rate (dural tear, root injuries and recurrent herniation) . More common in micro-endoscopic group.
Art et al. (2009)[7]	Patients with subacute symptoms	Microdiscectomy, N=161 vs micro-endoscopic discectomy, N=167	Significant effect in favour of microdiscectomy group regarding to functional improvement at 52 week. Non-significant effect b/w two groups regarding to pain relieve at 8, 52 week.
(2001) [8]			Non-significant difference b/w two groups regarding to pain relieve and functional improvement at 1, 2 years.
Franke et al. (2009) [25]	Patients with subacute symptoms	Microdiscectomy, N=48 MAPN procedure, N=52	No difference b/w two groups regarding pain relieve (back and leg), functional improvement and complicated rate at 8 week, 6 and12 month.

Table 6. Results reported in cohort studies comparing different surgical techniques in treatment of lumbar disc herniation.

Author Year	Participants	Treatment	Outcome and Follow-up
Katayama et al. (2006) [39]	Patients with subacute and chronic symptoms	Microdiscectomy, N= 57 vs open discectomy, N=62	No difference regarding to pain relieve b/w two groups at 1,2,3,4 years.
Porchet et al. (2009) [63]	Patient with subacute and chronic symptoms	Microdiscectomy, N=225 vs open discectomy, N=36	No difference regarding to pain relieve, overall and functional improvement at 3, 12 month.

Table 7. Results reported in systematic reviews comparing different surgical techniques in treatment of lumbar disc herniation.

Author Year	Participants	Treatment	Included trials	Outcome and Follow-up
Gotfryd et al. (2009) [27]	Patients with subacute and chronic symptoms	Microdiscectomy vs micro-endoscopic and open discectomy	7 RCT	Non-significant differences regarding to pain relieve and overall improvement were found b/w three groups. The main difference in rate of complication. Higher rate in micro-endoscopic discectomy group.
Jacobs et al. (2012) [33]	Patient with subacute and chronic symptoms	Microdiscectomy vs open discectomy	6 RCT	Moderate quality of evidence in favour of microdiscectomy regarding to pain relieve(leg) at 1 to 2.7 years follow-up.

*RCT- Randonized controlled trial

Table 8. Results reported in studies about factors which predict failures of conservative care and optimal timing of surgery

Author Year	Design	Participants	Follow-up	Outcomes
Takada et al. (2001) [85]	Prospective observational study	42 patients	24 month	Conservative care failure associated with large central protruding hernias and severe motor deficit.
Sutheerayon-gprasert et al. (2012) [81]	Case control study	100 patients	24 month	Conservative care failure associated with disc fragment size(> 8.7 mm), long duration of pain (22 weeks) and sequestered type of lesion.
Haugen et al. (2012) [30]	Prospective observational study	466 patients	24 month	Conservative care failure associated with long duration of pain (> 12 weeks) and muscular weakness at entrance clinical examination.
Rothoerl et al. (2002) [69]	Prospective observational study	219 patients	12 month	Conservative care failure associated with long duration of symptoms (more than 8 weeks). If symptoms don’t improve after 8 weeks surgery should be considered.
Takui et al. (2001) [84]	Retrospective study	249 patients	24 month	Conservative care failure associated with long duration of symptoms (more than 8 weeks). If symptoms don’t improve after 8 weeks surgery should be considered.

6. Discussion

6.1 Effectiveness of conservative types of treatment in therapy of lumbar disc herniation

The results of randomized controlled trials, systematic reviews that compare the conservative types of treatment in therapy of lumbar disc herniation are summarized in Table1 and Table2.

Medications

The most recent systematic review of Rafael Zambelli Pinto et al.(11 RCT) found small and non-significant effect of pain relieve (back and leg) in the immediate and short term for orally administered NSAIDs, antidepressants, opioid analgesics, anticonvulsants and corticosteroids compared with placebo. Only corticosteroids compared with placebo showed significant effect of pain relieve (back and leg) in the short term [61].

Similar results about NSAIDs and muscle relaxants compared with placebo were reached in two additional systematic reviews of Vroomen et al. and Luijsterburg et al.
Vroomen et al. (3RCT) during comparison of NSAIDs with placebo found no significant difference between NSAIDs and placebo in pain relieve after 5–30 days of follow-up [94].
Luijsterburg et al. (2RCT) found no difference regarding to pain relieve between NSAIDs and muscle relaxants with placebo in the short term [45].

However all 3 systematic reviews reports according to their authors, that only low quality evidence for pain relieve in the immediate and short term were used and thereby this data doesn't give the accurate evidence about prescription of oral medications for patients with lumbar disc herniation in primary care.

Although that patients with a clinical diagnosis of sciatica are about five times more likely to take drugs than those with low back pain only [61], there are only few studies that focus on the efficacy of oral medication that used in primary care in treatment of lumbar disc herniation.

Therapeutic Injection

Arden et al. performed the 12-month, multicentre, double-blind, randomized, placebo-controlled, parallel-group trial to determine the effectiveness and predictors of response to lumbar epidural corticosteroid injections (ESI) in patients with sciatica. 228 patients were randomized to three lumbar ESIs of triamcinolone acetonide or interligamentous saline injections at intervals of 3 weeks.

Study found that the most benefit ESI group demonstrated over the placebo group at 3rd week only in functional improvement. From 208 patients that completed the 52 week follow-up 60 patients achieved improvement in function before week 6.

From 6 to 52 week no benefits of ESI group over the placebo were demonstrated. In this period of time ESIs did not produce a significant improvement in relieve of pain (leg, back) and did not improve functional or overall improvement. At the end of the study the majority of patients still had significant pain and disability regardless of intervention [72].

Study show that the main benefit of ESI group over placebo is in functional improvement in the short term and ESI offer only short term relief of symptoms.

Additionally to this results Arden et.al conclude that there was no benefit of repeated ESIs over single injection [2].

Buchner et al. prospective randomized clinical trial evaluate the efficacy of conservative treatment in patients that suffering from lumbosciatic pain caused by herniated nucleus pulposus. Additional to ESI injection in this study both groups of patients got physical therapy treatment. 26 patients were randomized for two groups with 3 injections each. Study found that significant improvement of ESI group demonstrates only in pain relieve at 2nd week. Study show that the main benefit ESI group achieved regarding to pain relieve in the short term. Buchner et al. support like the previous author no benefit over single injection of ESI in treatment of lumbar disc herniation and recommends single ESI injection as additional therapy only in the acute phase of the conservative management of sciatica due to lumbar disc herniation [16].

Valat et al. in his multicenter randomized double blind, controlled clinical trial found the benefits of ESI over the placebo for relieve of the pain and functional improvement at day 20. At the end of the study (day 35), there was a marked improvement from baseline for pain relieve and functional improvement but no significant difference in favour of ESI [92]. The main difference of this study from previous was that patients received three epidural injections at two day intervals, while in previous studies interval between injections was 3 weeks.

Mclain et al. found in his systematic review (7RCT) conflicting evidence in benefit of ESI over the placebo for pain relieve (back, leg) and overall improvement in the short term. In the long term he found no benefit of ESI for pain relieve and overall improvement. But he found that patient who obtained relieve of pain from the first injection got benefit from a second or third injection. Additionally he found that in studies which long-term success rates for variety of cortocosteroid injections ranged from 71% to 84% the average number of injections was 1.8 [49].

Luijsterburg et al. found in his systematic review (13 RCT) conflicting evidence in benefit of ESI over the regarding to pain relieve and overall improvement at short term follow-up and no difference at long-term follow-up. For functional improvement was found no difference at short and long-term follow-up.

This systematic review compared additionally epidural or intramuscular corticosteroid injection to an injection of a NSAID or an anesthetic and found conflicting evidence for the benefit of corticosteroid injection over an injection with a NSAID or anesthetic regarding pain relieve at short-term follow-up. No difference between injections was found regarding pain relieved at long-term follow-up.

About injection with radioscopic control systematic review found the moderate evidence that an injection with radioscopic control is more effective than injection without radioscopic control regarding pain at intermediate follow-up and regarding functional improvement at short-term and intermediate follow-up for patients with LRS [45].

Thomas et al. in his prospective, randomised, double-blind study compared the respective efficacies of transforaminal and interspinous epidural corticosteroid injections in patient with sciatica for 6 month of follow-up. 31 patients were randomized for two groups. Study found the benefit of the TESI over ESI group regarding to functional improvement and pain relieve in the short term [87].

From the trials mentioned above the benefit of the ESI over placebo injection is in the short term. The benefit also depends on the interval of the injection, but not only. Some authors suggest that results of the clinical outcome can be seen already after first injection and if they are positive, followed injection can be considered. The results of clinical outcomes in favor of TESI over ESI group are obvious, but performing the TESI injection is complex and their cost is high.

Bed rest

Vroomen et al. in his randomized, controlled, blinded trial compared the bed rest to continuation of ADL during follow-up of 12 weeks and found that bed rest is not more effective in acute sciatica than continuation of ADLs. The patients in the bed-rest group were instructed to stay in the supine or lateral recumbent position with one pillow under the head for two weeks. They were permitted to get out of bed to use the toilet and to bathe. The patients in the continuation of ADL group were instructed to be up and about whenever possible but to avoid straining the back or provoking pain. They were allowed to go to work, but bed rest was not prohibited. After two weeks, 64 of the 92 patients in the bed-rest group (70%) and 59 of the 91 patients in the control group (65 %) reported improvement regarding to pain relieve (leg) and function improvement. After 12 weeks, 87% of the patients in both groups reported improvement in pain relieve (leg) and functional improvement [93].

Exactly the same results got Hofstee et al. in his Westeinde Sciatica Trial. He compared the efficacies of three nonsurgical treatment strategies (bed rest, physiotherapy, and continuation of ADLs (control treatment)) in patients with acute sciatica during follow up at 1, 2, and 6 months. Patients assigned to bed rest at home or in-hospital were instructed to stay in bed for 7 days. They were only allowed out of bed to use the bathroom and shower. After this period, the patients were supposed to rest as much as possible when in pain. Study didn't find significant differences between two groups in pain relieve, overall improvement and functional improvement at 1, 2, and 6 months [31].

From the trials mentioned above the obvious conclusion is that bed rest doesn't has any efficacy in treatment of lumbar disc herniation.

Physiotherapy

Hofstee et al. randomized controlled trial compared the efficacies of three nonsurgical treatment strategies as we mentioned previously (bed rest, physiotherapy, and continuation of ADLs (control treatment)). The protocol of physiotherapy consisted of instructions and advice, segmental mobilization, disc unloading and loading exercises, depending on patients' conditions, and hydrotherapy. Patients that included in the study were suffering from symptoms of LDH less than 4 weeks and were scheduled to visit the physiotherapy department twice a week for at least 4 to, at most, 8 weeks. They were also asked to perform daily exercises at home.

Patients assigned to the control group (continuation of ADLs) were instructed by the investigators to continue their jobs, household activities, studies, or hobbies to the best of their abilities. They were advised to adjust the intensity, duration, and frequency of their activities according to the pain they experienced.

147 patients completed 6 months of follow-up period. Study found that physiotherapy compared to continuation of ADLs not significantly different in outcome measures regarding to pain relieve, overall and functional improvement at 1, 2, and 6 months. Study concluded that physiotherapy is not more effective in acute sciatica than continuation of ADLs [31].

The same results relative to comparison of physiotherapy with other conservative treatment of lumbar disc herniation found Luijsterburg et al. in his systematic review.

Review compared the clinical trials (2 RCT) in which the physiotherapy compared to other conservative treatments like: traction, manipulation, exercise and corset wearing.

No difference regarding to pain and overall improvement were found in comparison of physiotherapy with other conservative treatments at short time of follow-up [45].

To assess the effectiveness of physiotherapy in treatment of lumbar disc herniation Luijsterburg et al. compared physiotherapy treatment additional to general practitioners' care vs. general practitioners' care alone in patients with acute sciatica due to lumbar disc herniation with a 12-months follow-up period.

135 patients with acute sciatica duration less than 6 weeks were randomized in two groups: the intervention group (67 patients) received PT added to the general practitioners' care and the control group (68 patients) with general practitioners' care only.

General practitioners gave information and advice about LRS and, if necessary, prescribed (pain) medication. Physiotherapy treatment consists of exercise therapy as well as giving information and advice about LRS. Passive modalities such as massage and manipulation techniques or applications such as ultrasound therapy or electrotherapy were not allowed.
In both groups patients improved over time. At 3, 6 and 12 weeks there was no significant difference between the two groups regarding to overall improvement.
At 12 months follow- up, there was a significant and a clinical difference between the groups regarding to overall improvement in favor of the intervention group. About 53 patients (79%) in the intervention group versus 38 patients (56%) in the control group reported to be 'improved'
No significant differences regarding pain (leg) relieve, functional improvement, and quality of life were found at short-term or long-term follow-up. Only one difference was found at 12 months follow-up, that PT added to general practitioners' care is more effective regarding to overall improvement in the treatment of patients with acute sciatica than general practitioners' care alone [44].

From the trials mentioned above the physiotherapy compared to continuation of ADL and other treatments has no benefit in the therapy of lumbar disc herniation in the short to long time of follow-up. Only educational part of the physiotherapy has efficacy regarding to overall improvement in the therapy in the long term of follow-up.

Traction

Rattanatharn et al. performed randomized double-blind controlled trial to assess the effectiveness of lumbar traction with routine conservative treatment in acute herniated disc syndrome with 4 weeks of follow-up. 120 patients were enrolled in the study. The study group received traction, and the control group received sham traction. All patients had routine conservative treatments (consisting of NSAIDs, instruction of proper back activity and precaution, back exercise, and heat modality).
At 4 week of follow-up there was no significant difference between the two groups regarding to functional and overall improvement. Approximately 89% of patients in each group had functional improvement, and 90% in each group were satisfied with lumbar traction. Study didn't found benefit of traction for patients with acute herniated disc syndrome [65].

The same results relative to comparison of traction to inactive/shame traction or other conservative treatments in treatment of acute lumbar disc herniation found Luijsterburg et al. in his systematic review.

Review compared the clinical trials (4 RCT) in which traction compared with inactive/shame traction and found no difference between two methods regarding pain relieve and functional improvement at short-term follow-up. When traction was compared with other conservative treatments (manipulation, exercise therapy) for patients with LRS (5 RCT) systematic review found conflicting evidence regarding to overall improvement and pain relieve at short-term follow-up [45].

From the trials mentioned above the traction compared to inactive/shame traction or other conservative treatments (manipulation, exercise therapy) has no benefit in the therapy of lumbar disc herniation in the short term.

6.2 Effectiveness of surgery versus conservative treatment in therapy of lumbar disc herniation

The results of randomized controlled trials and observational cohorts that compare the surgical vs. conservative treatment are summarized in Table 3 and Table 4.

Osterman et al. compared microdiscectomy and conservative management in prospective randomized controlled trial for 2 years of follow-up. 56 patients with sciatica for at least 6–12 weeks were enrolled in the study and randomized for two groups: microdiscectomy group and controlled group with active physiotherapeutic instructions, including stretching, bending, and muscle strengthening exercises. Eleven patients in the control group from 28 initially allocated to surgery crossed over to surgery. The primary outcome measure was pain relieve (leg) and the secondary outcome measures included pain relieve (back), functional and overall improvement.

In the intent-to-treat analysis, at each follow-up (6 weeks, 3 and 6 months and 1 and 2 years) the surgical group fared better, but the differences in group means were statistically significant only for pain relieve(leg) at 6 weeks and for overall improvement at 6 weeks, 6 months, and 2 years. The study showed no statistically significant differences between the two groups in pain relieve (back, leg), and functional improvement over the 2-year follow-up. In a subgroup analysis, discectomy was superior to conservative treatment when the herniation was at the L4–L5 level [83].

There was significant improvement over time in both groups, but in surgery group results were better. At 6 weeks patients in surgical group had less leg pain and significant overall improvement. This can be considered as faster recovery and benefit of surgery in the short term over conservative care, but this result have been interpreted with caution because of small sample size of this study [57].

Weinstein et al. compared surgical vs. nonoperative treatment in the SPORT (Spine Patient Outcomes Research Trial) trial conducted in the 11 US states at 13 medical for 2 years of follow-up. One part of the study included 501 patients with sciatica for at least 6 weeks who were randomized into two groups (surgery vs. conservative) [97]. Second part included 719 patients with sciatica for at least 6 weeks in the observational cohort who chose one of the two treatment options (surgery or conservative) [98]. The surgery was a standard open discectomy and conservative care included active physical therapy, education and counseling with home exercise instruction, epidural injections, and nonsteroidal anti-inflammatory drugs.

In the randomized clinical trial adherence to assigned treatment was limited. 50% of patients assigned to surgery received surgery within 3 months of enrollment, while 30% of those assigned to nonoperative treatment received surgery in the same period.

In the intent-to-treat analysis both operated and nonoperated patients improved substantially over a 2-year period. Primary measures regarding to overall and functional improvement for both treatments groups showed strong improvements at each of the designated follow-up times(3 months, 1 year, and 2 years), with small advantage for surgery. Secondary measure regarding to pain relieve showed greater improvements in the surgery group at all designated follow-up times: 3 months, 1 year and 2 years.

The as-treated analysis, substantial improvements was for all primary and secondary outcomes in both treatment groups, but between-group differences in improvements were consistently in favor of surgery for all follow-up periods (3 months, 1 year, and 2 years) with small and not statistically significant for the primary outcomes and strong statistically significant for the secondary outcome [97].

In the observational cohort 521 patients initially chose surgery and 222 patients initially chose conservative care. Patients who chose surgery had worse baseline symptoms and functional status than patient in nonoperated group.For the group initially choosing surgery, 91% received surgery within 6 weeks of enrollment, with an additional 4% receiving surgery by 6 months; at 2 years 4% remained nonoperative. In the group initially choosing nonoperative treatment, 2% underwent surgery in the first 6 weeks, while 16% had surgery by 6 months, and 22% had surgery by 2 years. During the study 528 patients received surgery and 191 received usual conservative care.

In the intent-to-treat analysis, there was substantial improvement over time of 2 year period in both conservative and surgery groups of patients, but greater results were in those patients who underwent surgery. Treatment effects were statistically significant in favor of surgery at 3 months. At 3 months, patients who chose surgery had greater improvement in the primary outcome measures regarding to overall and functional improvement. The secondary measure regarding to pain relieve also demonstrated significant treatment effects at 3 month in favor of surgery group. The treatment effects narrowed between 3 months and 2 years but remained significant in favor of surgery group at all periods [98].

In the 4-year combined as-treated analysis, surgery group demonstrated significantly greater improvement in all the primary and secondary outcome measures than non-operatively treated patients [99].

There was significant improvement over time in both groups, but patients in the surgery group had better primary and secondary outcome measures for all follow-up periods. With the primary outcome at 3 months, benefit of surgery group over nonoperative treatment for pain relieve, functional and overall improvement were marked and maintained over 4 years.

Atlas at al. compared surgical and nonsurgical management in prospective observational study to assess 10-year outcomes of patients with sciatica in Maine. 507 patients with sciatica for at least 6 month were enrolled in the study. Follow-up was obtained by mailed questionnaires at 3, 6, 12, 60 and 120 months. Treatment, either surgical or nonsurgical care, was not prescribed by the study but was determined in a routine clinical manner by the patient and the physician. 95.9% of patients who choose surgery underwent open discectomy and patients electing nonsurgical treatment, back exercises, physical therapy, bed rest, spinal manipulation, narcotic analgesics, and epidural steroids were most frequently used. Surgically treated patients had worse baseline symptoms and functional status than those initially treated nonsurgically.

In the intent-to-treat analysis, at the 1-year of follow-up, improvement regarding to overall and functional improvement were found in both treatment groups. However, surgically treated patients reported significantly greater improvement. For the pain relieve (back, leg) 71% of surgically treated and 43% of conservatively treated patients reported definite improvement [4].

In the intent-to-treat analysis, at the 5-year of follow-up, patients treated initially with surgery reported better outcomes. 70% of patients initially treated surgically reported improvements in pain relieve (back, leg) versus 56% of those initially treated nonsurgically. Overall improvement at the 5-year of follow-up was also significantly better among those treated surgically. Overall improvement of the patient’s current state was reported by 63% of surgically treated patients versus 46% of nonsurgically treated patients [5].

In the intent-to-treat analysis, at the 10-year of follow-up, slightly higher percentage of patients treated surgically reported improvement in pain relieve(back) compared with patients treated nonsurgically (69% vs. 59%), but improvement in pain relieve(leg) was similar in both treatment groups. Surgically treated patients reported significantly greater improvement regarding to functional improvement and pain relieve. The predominant symptoms of pain were reported to be “much better” or “completely gone” in 56% of surgical patients compared with 40% of nonsurgical patients. Overall improvement of the patient’s current state was reported by 70.5% of surgically treated patients versus 55.5% of nonsurgically treated patients [6].

There was significant improvement over time in both groups, but the surgery group had benefit for outcome measures regarding to pain relieve (back, leg), overall and functional improvement for all follow-up periods (1, 5, 10 years). By 10 years, 25% of surgical patients had undergone at least one additional lumbar spine operation, and 25% of nonsurgical patients had at least one lumbar spine operation [89]. The limitation criterion of this study on my opinion is that patients who choose surgery treatment had worse symptoms from the beginning and their improvement in outcome measures was stronger.

Peul et al. conducted randomized controlled trial to evaluate the effects of early lumbar disc surgery compared with prolonged conservative care for patients with 6-12 weeks of persistent sciatica over two years of follow-up. 283 patients were randomized for one of two groups: microdiscectomy and prolonged conservative management (six months ofcontinued conservative treatment, with delayed surgery if need). Early surgery was scheduled within 2 weeks from assignment and prolonged conservative treatment was provided by general practitioners. Conservative treatment included the resuming of daily activities, prescription of effective painkillers and for patients who had fear of movements assigned to a physiotherapist.

Primary outcome measures were pain relieve (leg) and functional improvement at 2, 4, 8, 12, 26, 38, 52, 78, and 104 weeks. Secondary outcome measures were pain relieve (back) and overall improvement at 8, 26, 52, 78, and 104 weeks.

In the intent-to-treat analysis, during the first 12 weeks after randomization outcome measures regarding to pain relieve (leg) and functional improvement improved significantly faster in the early surgery group. The benefit of early surgery was no longer significant by six months and continued to narrow between six months and 24 months. After the 24 week outcome assessment, no significant differences were found between the treatment groups for any of the outcome measures (pain relieve (back, leg) and functional improvement) at any of the remaining assessments. Overall improvement decreased slightly between one and two years for both groups. At two years 20% of all patients reported an unsatisfactory outcome in both groups [64].

Study concludes that early surgery in patients who had sciatica for 6-12 weeks provided faster recovery and reducing of the pain than prolonged care. However, primary and secondary outcome measures were similar after one year and these results remains during the second year.

In a general view mentioned above trials the surgical treatment has significant benefit in all clinical measures over the nonoperative treatment. However, there are some differences between studies that influence their outcome results. Results of randomized controlled trials show significant improvement in pain relieve in the first 3-6 month in favor of surgery and not statistically significant benefit of surgery over conservative treatment for functional and overall improvement at 1- 2 years of follow-up. Results of observational cohort show significant improvement in pain relieve, overall and functional improvement in favor of surgery for 2- 10 years of follow-up. It can be achieved by patients who choose surgery because of initially worse symptoms and their recovery would be better comparing to those patients who choose initially conservative treatment. We can conclude that surgery provide faster relief of the symptoms, specially leg pain in patients with lumbar disc herniation, but the clinical results after one year of the surgery and conservative treatment are similar.

6.3 Effectiveness of surgery intervention in therapy of lumbar disc herniation

The results of randomized controlled trials, systematic reviews and prospective studies that compare the surgical interventions with focus on the three surgical techniques (open discectomy, microdiscectomy and micro-endoscopic discectomy) are summarized in Table 5, Table 6 and Table 7.

Porchet et al. prospective study compared the outcomes following open discectomy and microdiscectomy for 1 year of follow-up. From 261 patients suffering from LDH that their symptoms were lasting more than 6 weeks 225 patients underwent mocrodiscectomy and 36 patients underwent open discectomy.

In the intent-to-treat analysis, at the 3 month of follow-up, measures outcome of patient underwent open discectomy reported slightly better improvement in pain relieve (leg) compared with patients underwent microdiscectomy, while overall improvement and pain relieve(bag) was similar in both treatment groups.

In the intent-to-treat analysis, at the 1 year of follow-up, measures outcomes of patient underwent open discectomy regarding to pain relieve(back,leg) and overall improvement were similar compared with patients underwent microdiscectomy.

The main difference between two surgical interventions were significantly greater blood-loss during operation in open discectomy underwent patients than in microdiscectomy underwent patients [63].

This results show that during comparison of two surgical interventions there was no clinically relevant difference in outcome measures and both procedures are suitable for therapy of lumbar disc herniation equally.

Jacobs at al. systematically reviewed the clinical trial (6 RTC) which compared the classical open discectomy with microdiscectomy in patients with sciatica due to disc herniation, who have indications for surgical intervention. The main result of this systematic review regarding to outcome measures was moderate quality of evidence that pain relieve (leg) was statistically significantly less for microdiscectomy at follow-up range from 1 to 2.7 years [33]. The limited criterion of this systematic review was that 5 studies from 6 included were with high risk of bias, so the clinical result regarding to pain relieve (leg) in favor of microdiscectomy in this systematic review can be considered as limited quality, but other outcome measures show that two surgery procedure are suitable for therapy of lumbar disc herniation equally.

Katayama et al. prospective study compared two surgical techniques (open discectomy and microdiscectomy) in patients suffering from lumbar disc herniation performed by the same surgeon for 4 years of follow-up. 119 patients with symptoms lasting over 6 weeks of conservative management were enrolled in the study. 62 patients underwent open discectomy and 57 patients underwent microdiscectomy.

In the intent-to-treat analysis, at the 1,2,3,4 year of follow-up, results of outcome measures were not significant difference between two surgical groups regarding to pain relieve (back and leg). The main statistically significant differences were observed regards to the amount of bleeding loss and duration of hospitalization in favour of microdiscectomy group [39].

The study show that the differences between two surgical procedures are not clinical results, which their outcome measures have not significant difference between them. The difference is the performed technique of the microdiscectomy that reduce amount of bleeding and duration of hospitalization.

Marco Teli et al. randomized controlled trial compared the outcomes and complications obtainable with three common surgical techniques (micro-endoscopic discectomy, microdiscectomy and open discectomy) in patients suffering from LDH with symptoms lasting over 6 weeks for 2 years of follow-up. 240 patients were randomized for three surgical groups and 212 patients completed the 24-month follow- up period (91%).

In the intent-to-treat analysis, at the 6-, 12- and 24-month of follow-up, the outcome measures of pain relieve (back and leg), functional improvement and quality of life showed clinically and statistically significant improvements within groups without significant difference among groups. The main differences in three groups were complications like dural tears, root injuries and recurrent herniations that were significantly more common in group of micro-endoscopic discectomy [86].

This study show that the main differences between surgery procedures are not results of clinical outcome measures. The main differences were the surgery complication, which their rate and type were more common and serious in patient underwent micro-endoscopic discectomy.

Gotfryd et al. systematically reviewed the clinical trial (7 RCT) that compared the efficacy of three different discectomy techniques (open discectomy, microdiscectomy, micro-endoscopic discectomy) using a posterior approach for the treatment of LDH in patient who didn't respond for conservative care. This systematic review didn't found statistically significant differences between these techniques regarding to pain relieve and overall improvement. Current data of this systematic review suggest that the microdiscectomy and endoscopic techniques are superior to the classic open discectomy technique for the treatment of single level lumbar disc herniations [27].

This systematic review show that all three surgical techniques were found to be effective for the treatment of the lumbar disc herniation, however the less volume of blood loss, and less duration of hospital stay were found in microdiscectomy and micro-endoscopic discectomy.

Arts et al. randomized controlled trial compared two surgical techniques: tubular discectomy and conventional microdiscectomy to determine outcomes and time to recovery in patients with sciatica due to lumbar disk herniation. 328 patients that their symptoms lasted more than 8weeks and were refractory to conservative treatment were enrolled in the randomized trial (tubular discectomy, n=167; conventional microdiscectomy, n=161).

In the intent-to-treat analysis, the outcome measure of pain relieve (leg and back) showed improvement in both groups during the first year (4, 8, 26, and 52 weeks) after surgery. However, patients who underwent conventional microdiscectomy reported less pain (leg and back) than those treated with tubular discectomy and the difference was statistically significant in favor of conventional microdiscectomy.

The outcome measure of functional improvement showed improvement in both groups during the first year (8 and 52 weeks) after surgery. At 8 weeks difference was not significant, but at 52 week this difference was statistically significant and favored conventional microdiscectomy.

At 1 year, 107 of 156 patients (69%) assigned to tubular discectomy reported a good recovery vs 120 of 151 patients (79%) assigned to conventional microdiscectomy.

The intraoperative complication rate was 12% (n = 20) for the tubular discectomy group and 8% (n=13) for the conventional microdiscectomy group. Dural tear was the most common complication in both groups but the difference was not statistically significant.

The postoperative complication rate was 11% (n=19) for the tubular discectomy group and 9% (n=14) for the conventional microdiscectomy group. At 1 year, the reoperation rate was

10% (n=17) after tubular discectomy and 7% (n=11) after conventional microdiscectomy. The reason for repeated surgery was recurrent disc herniation in 71% (n=20) of the cases [7]. At 2 years after surgery there was no significant difference between tubular discectomy and conventional microdiscectomy in functional improvement. Patients treated with tubular discectomy reported more pain (leg and back) than those patients treated with conventional microdiscectomy. After 2 years 71% of patients assigned to tubular discectomy documented a good recovery vs 77% of patients assigned to conventional microdiscectomy. Repeated surgery rates within 2 years after tubular discectomy and conventional microdiscectomy were 15% and 10%, respectively [8].

In contrast to other studies, this study show that patients have significant improvements in pain relieve (back, leg) and functional improvement in favour of microdiscectomy for all follow-up periods. These findings are opposite to all results of the previous studies. However, this study had limitation that should be mentioned. Only patient with large herniated discs and distinct nerve root compression were included.

During this study Arts et.al checked if concept of minimally invasive lumbar disc surgery comprises reduce of muscle injury. It was done by monitoring of evaluation creatine phosphokinase (CPK) in serum and the cross-sectional area (CSA) of the multifidus muscle on magnetic resonance imaging as indicators of muscle injury. In 216 patients, CPK was measured before surgery and at day 1 after surgery. In 140 patients, the CSA of the multifidus muscle was measured at the affected disc level before surgery and at 1 year after surgery. The ratios (i.e. post surgery/pre surgery) of CPK and CSA were used as outcome measures. The multifidus atrophy was classified into three grades ranging from 0 (normal) to 3 (severe atrophy), and the difference between post and pre surgery was used as an outcome.

Tubular discectomy compared with conventional microdiscectomy resulted in a non significant difference in CPK ratio, although the CSA ratio was significantly lower in tubular discectomy. At 1 year, there was no difference in atrophy grade between both groups nor in the percentage of patients showing an increased atrophy grade (14% tubular vs. 18% conventional). Study concluded that tubular discectomy compared with conventional microdiscectomy did not result in reduced muscle injury. Postoperative evaluation of CPK and the multifidus muscle showed similar results in both groups [9].

Franke et.al randomized controlled trial compared standard microsurgical discectomy (MC) and a minimally invasive microscopic procedure (MAPN) for disc prolapse surgery. 100

patients that their symptoms lasted more than 6 weeks and were refractory to conservative treatment were enrolled in the study. Surgery procedures were provided in two centers: experienced (index) centre and a less experienced MAPN (transfer) centre with a 12-month follow-up.

The clinical outcome of both surgical methods was indistinguishable at the transfer centre, whereas MAPN patients at the index centre showed a slightly faster recovery when compared to MC patients. This was mainly due to the fact the there was a more

improvement in the pain relieve(back). This phenomenon reached statistical significance at discharge at 8 weeks and 6-month follow up. For the 12-month follow up this difference could not be found. No difference was found for the pain relieve (leg) at any of the time points. The same analyses for the transfer centre did not show any difference in pain (back and leg) relive at any time point, indicating that there was no statistical significant difference in clinical outcome for these two methods at the transfer centre.

There were no differences regarding to the overall improvement and complications for the two methods in either centre. The main difference was in shorter operation duration and concomitant quicker recovery in the experienced minimally invasively operating centre. These advantages could not be found at the transfer centre [25].

This study show that in experienced centre outcome measure of pain relieve (back) was better and rate of complication was less than in not experienced center for the same surgery techniques. These findings emphasize how clinical results and complication can be influence from the experienced and not experienced surgeon.

In a general view mentioned above trials that compare three surgical techniques (micro-endoscopic discectomy, microdiscectomy and open discectomy) the microdiscectomy technique has benefits over two other surgical techniques.

The benefit of the mocrodiscectomy over open discectomy is the less blood loss and duration of hospitalization, while the clinical outcome measures are similar. The second benefit is that microdiscectomy is less invasive than open discectomy.

The benefits of the microdiscectomy over micro-endoscopic discectomy are the pain relieve and less complicated rate. Additionally micro-endoscopic discectomy relatively new surgery techniques and not all surgeons experienced to provide it, and this can influence the clinical outcomes measures.

6.4 Factors which predict failures of conservative care and optimal timing of surgery

The results of studies which predict factors of failures of conservative care and optimal timing of surgery are summarized in Table 8.

Takada et al. studied the relationship between the MRI changes and the type of LDH and the clinical outcome. 42 patients with radicular leg pain and symptoms definitely diagnosed as caused by LDH were treated conservatively and followed up by serial MRI for a period of 3–24 months. LDH was classified into three types: protrusion (n=7), extrusion (n=17) and sequestration (n=18). The symptomatic disc level was L2-L3 in 8 cases, L3-L4 in 6 cases, L4-L5 in 15 cases and L5-S1 in 13 cases.

The recovery of symptoms, especially radicular leg pain, preceded the involution of the herniated mass on MRI. In the patients with sequestrated LDH, severe radicular leg pain was the initial symptom and the pain improved 1–5 weeks after the onset (average: 3.2w), leaving sensory changes or a motor deficit, while a permanent severe motor deficit was observed in six cases. In the patients with extruded LDH, radicular leg pain was not so severe compared to the patients with sequestration and leg pain lessened 4–8 weeks after the onset(average: 4.8w). Patients with the protruded LDH usually complained of leg pain on walking and improved after 3–14 weeks (average: 8w). 4 patients from 7 initially enrolled in the study with this type of hernia showed no MRI changes and had no decrease of their leg pain.

Study found that only patients with the protruded LDH didn't improve during more than 12 month of follow-up period.

Conclusion of the study was that surgery may be necessary for large central protruding hernias and patients who show severe motor deficits [85].

Sutheerayongprasert et al. performed case-control study to explore factors predicting failure of conservative treatment in therapy of lumbar-disc herniation. Medical records of 100 patients who diagnosed with lumbar-disc herniation were studied. Fifty cases (surgery treated who failed 6 weeks of conservative treatment) and 50 controls (successful conservative treatment with at least six months follow up period without significant recurrent pain) were enrolled between 2007 and 2009 and compared, for clinical features, MRI results and treatment modalities. Nearly half the herniation occurred at the L4-5 level (49%), followed by the L5-S1 level (35%). Forty-four percent were of the extruded type, followed by protruded (30%) and sequestered (26%) types. Most cases (74%) had posterolateral herniation.

Study found that disc fragment size (> 8.7 mm AP diameter), long duration of pain (> 22 weeks) and sequestered type of lesion were strong associated with surgery.

Study showed that average duration of pain in successful conservative control group was 4.9 week whereas average duration of pain in patient undergoing surgery was 22.7week.

Study conclude that long-duration of symptoms, sequestered herniation and large fragment are predictive of failure in the conservative treatment of lumbar-disc herniation [81].

Haugen et al. performed the a prospective multicentre observational study including 466 patients with sciatica and lumbar disc herniation to identify factors associated with non-success after 1 and 2 years of follow-up and to test the prognostic value of surgical treatment for sciatica.142 patients with severe symptoms were treated surgically and 234 patients were treated with conservative treatment.

Study showed that 44%–47% of the patients with sciatica had a non successful outcome at 1 year and 39%–42% at 2 years. The main prognostic factors for non-success at both 1 and 2 years were: duration of leg pain more than 3 month, muscular weakness at entrance clinical examination [30].

Rothoerl et al. performed prospective study to determine when conservative treatment for lumbar disc herniation can be stopped and surgery intervention considered. 219 patients with symptoms due to lumbar disc herniation less than 30 days 30–60 days and more than 60 days were enrolled in the study and underwent surgery on monosegmental lumbar disc herniations for the first time with follow-up of 10 months.

Study found that statistically significant predictors for unfavorable outcome were a longer duration of preoperative pain (>69 days onset symptoms), paresis (>54 days onset symptoms), and sensory deficit (>37 days onset symptoms).

In order to find out at which time point the durations of symptoms(pain, sensory and motor deficit) become statistically significant predictors for unfavorable outcome, several groups were formed (≤30 days, 30–60 days, and >60 days).

Study found that patients suffering from a symptomatic lumbar disc herniation for less than 30 days showed no statistically different outcome than patients suffering for more than 30 days.

In contrast, patients suffering for more than 60 days from symptomatic disc herniation were found to have statistically worse outcome than patients suffering for less than 60 days.
Due to this finding, study recommended conservative treatment for up to 2 months. If there is no improvement in symptoms and signs, surgery should then be considered without further conservative treatment options [69].

Takui et al. performed a retrospective study of different types of herniated discs and duration of symptoms in patients with lumbar disc herniation, and a trial of longer conservative treatment to reduce the number of operations. In the first study, the medical history and intraoperative findings of 156 patients who had undergone herniotomy were reviewed. In the second study, conservative treatment of at least 2 months' duration was recommended for all patients with lumbar disc herniation.
The first study found that it was rare for surgery to be performed 2 months or more after the onset of symptoms in patients with noncontained herniation (transligamentous extrusion and sequestration) and extremely rare after 4 months.
Study concluded that symptoms in patients with noncontained disc herniation do not remain severe for more than 2 months. Therefore, study 2 was performed. In this study, the number of herniotomies, especially those in patients with noncontained disc herniations, was reduced under the authors' clinical protocol. All patients had no severe complications and was regarding to patient who has noncontained disc herniation.
In contrast to noncontained disc herniation study found that symptoms in patients with contained herniation (protrusion and subligamentous extrusion) last longer, and operative treatment was necessary even 4 months after the onset of symptoms.
Study recommended that conservative treatment for all patients with lumbar disc herniation within 2 months after the onset of their symptoms, except for patients with cauda equina syndrome or severe motor weakness. Surgical treatment recommended when the symptoms continue for 2 months or longer, or when patients have compelling reasons [84].

7. Conclusion

This thesis completed literature review of the efficacy of conservative and surgical treatment in management of lumbar disc herniation that included 33 clinical trials and 6 systematic reviews which were evaluated according to their results with conclusion.

The treatment strategy of patient with lumbar disc herniation initially is conservative and primarily aimed in reducing of pain. Based on the reviewed clinical trials and systematic reviews it is possible to conclude that from all commonly available conservative methods only few of them evidently improve the patient condition. The most significant result for reduce of the pain was reached in patients with lumbar disc herniation by using corticosteroid injections in the short term. The other useful method of conservative treatment in the long term for overall improvement is educational part of physiotherapy that includes: appropriate information and advices to deal with lumbar disc herniation.

For surgical intervention based on relevant sources according to three surgical techniques (open discectomy, microdiscectomy and micro-endoscopic discectomy) for treatment of lumbar disc herniation it is possible to conclude that there is no significant differences in clinical results between three surgical techniques that were observed in this thesis. However the microdiscectomy technique of surgery has evidently less post-operative complications compared to open and micro-endoscopic discectomy techniques of surgery in treatment of lumbar disc herniation.

In comparison of two main approaches (surgery versus conservative treatment) based on the relevant sources it is possible to conclude that both methods are relevant in treatment for patients with lumbar disc herniation of at least 6-12 weeks duration and there is not significant differences in clinical results between them in the long term follow-up (6- 24 month). In the intermediate follow-up (till 6 month) surgery treatment provides significantly better clinical results specially regarding to reduce of the radicular leg pain and improving of functional status than conservative treatment.

Based on the findings that were found in the relevant sources the hypothesis which was proposed during the work on this thesis can be considered as confirmed. Accordingly to this it can be accepted that patients with lumbar disc herniation whose symptoms have not improved during 6-12 weeks, the most appropriate treatment option for them in reducing of symptoms can be considered the surgery intervention.

According to my opinion the theme of this thesis is very important in our days in connection with modern style of life of people. Sedentary lifestyle, reducing of daily physical activity, the presence of aggravating factors (as smoking, obesity, etc) suggests that the number of patients that will suffer from lumbar disc herniation will increase and this theme will be stay actual and relevant for future researching.

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