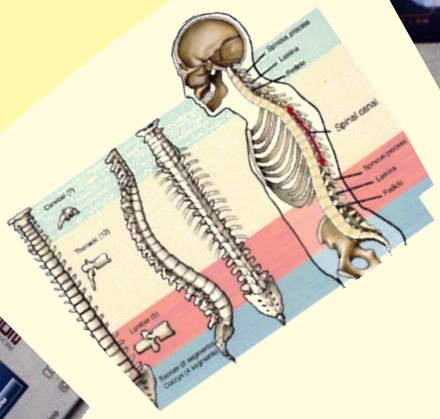
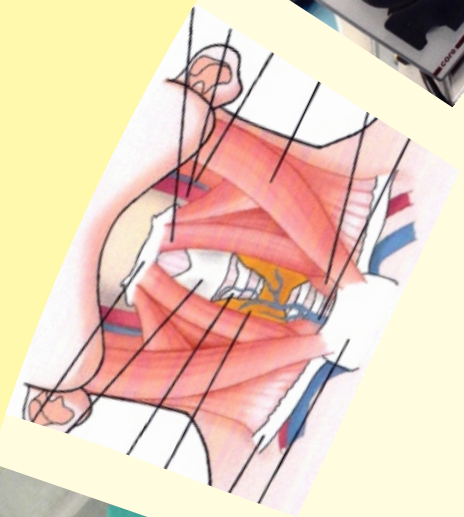
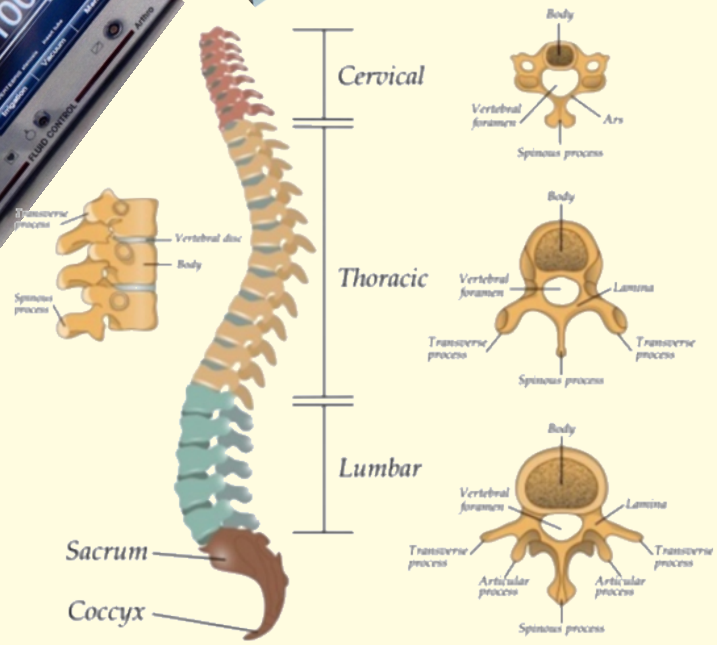
COMPREHENSIVE GUIDE TO ENDOSCOPIC SPINE SURGERY







STATE INSTITUTE OF HEALTH AND FAMILY WELFARE
UTTAR PRADESH

ACKNOWLEDGEMENTS

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MESSAGE

Shri Brajesh Pathak
Hon'ble Deputy Chief Minister
Minister of Medical Health and Family Welfare
Department Government of Uttar Pradesh

Globally, there have been rapid developments in the prevention, diagnosis, and comprehensive management of various spinal ailments. This assumes importance since spinal problems pose a grave challenge to humanity. Lower back pain, for example, is among the top 10 causes for the highest number of disability-adjusted life years lost worldwide. Furthermore, it is the leading cause of disability and work absence, causing a great economic burden. Spinal cord injury (SCI), on the other spectrum, is considered the most devastating ailment to afflict mankind.

The challenge becomes multifold in resource-challenged countries like India. Numerous factors such as the inadequacy and inaccessibility of services, the non availability of multidisciplinary comprehensive care, the lack of a barrier-free environment, and financial constraints hinder the comprehensive management of SCI and other spinal ailments, further contributing to this challenge. There remains a vast imbalance in the availability of specialized spine services between urban and rural areas in the state due to the aggregation of tertiary centers in cities and a lack of a systematic referral system for spinal ailments. In Uttar Pradesh state, we have to work holistically not only in assessing health conditions of the older population but also in treating spinal issues with minimally invasive interventions.

Considering the above stated facts, through the Continuing Medical Education module on Comprehensive Guide to Endoscopic Spine Surgery, Medical Officers in Provincial Health & Medical Services in Uttar Pradesh will be exposed to much needed training.

I wish the team of State Institute of Health & Family Welfare, Uttar Pradesh and subject matter experts to continue developing such module on CME for the benefit of Medical Officers in Provincial Health & Medical Services in Uttar Pradesh that ultimately benefit their patients too.

Brajesh

(Brajesh Pathak)

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MESSAGE

Shri Mayankeshwar Sharan Singh

Hon'ble State Minister
Medical Health and Family Welfare
Department Government of Uttar Pradesh

Apart from working routinely as clinicians and surgeons, Medical Professional can always contribute in improving the public health scenario. They could do this by ensuring that they are well versed with recent developments in spine care with a view to improve outcomes and focusing on research activities in an endeavor to find novel solutions, especially those relevant to the Indian scenario.

This covers not only bridging the gap in service delivery in the underprivileged areas/sections of the society; setting up centers for treatment, research, or training for spinal problems; creating awareness about prevention; and providing recommendations to policymakers but also employing minimally invasive treatment and surgical techniques to address health related issues especially for the older population.

In order to further strengthen and broaden the range of preventive and health care services for older population, Continuing Medical Education module on Comprehensive Guide to Endoscopic Spine Surgery for Medical Officers in Provincial Health & Medical Services in Uttar Pradesh is one of the best suitable interventions in this direction.

I am happy that the team at State Institute of Health & Family Welfare, Uttar Pradesh(SIHFW, UP) along with the experts from the field, have come up with such an intensified and detailed CME for Medical Officers in Provincial Health & Medical Services in Uttar Pradesh.

I wish team at SIHFW success in their endeavors of aiding an improved health service delivery system through such CME on Endoscopic Spine Surgery.

(Mayankeshwar Sharan Singh)

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FOREWARD

Shri Partha Sarthi Sen Sharma

Principal Secretary
Department of Medical, Health and Family Welfare
Government of Uttar Pradesh

In the near future, our country will face a challenge with a rapid increase in the number of aged and the associated health and social issues, as large bulk of population will move from working ages to old ages, thereby increasing the old age dependency. There is a pressing need to pay attention to the well-being of the elderly as diseases and disorders affecting older adults are on the rise.

As the population continues to age, spinal disease will become more prevalent in the elderly population. The treatment of spinal disease requires an individual approach incorporating best practices. Optimal management in the elderly may differ from younger patients due to increased co-morbidities, decreased bone health, and a higher risk of preoperative morbidity and mortality.

While more and more elderly patients will require evaluation and management of their spinal disease, most healthcare practices discuss operative and nonoperative management based upon disease process. Techniques and approaches are adopted for a specific pathology, and are usually tailored for a young or middle aged patient.

Under this context, it is pertinent that we should revisit the health care intervention in the state to foretaste our level of preparedness in embracing this challenge. This then necessitates the need for specialized training of medical officers in spinal surgery.

This Continuing Medical Education (CME) module on Comprehensive Guide to Endoscopic Spine Surgery for Medical Officers in Provincial Health & Medical Services in Uttar Pradesh, has been developed with the intent to impart latest knowledge that address the spinal issues with minimally invasive techniques, so that the Medical Officers might stay abreast of the rapidly evolving practices in the field.

I would like to take this opportunity to congratulate State Institute of Health & Family Welfare (SIHFW), Uttar Pradesh and other Subject Matters Experts in developing such a comprehensive module. I hope this CME module will prove to be an asset in taking care of our elderly population.

(Partha Sarthi Sen Sharma)

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MESSAGE

Dr. Deepa Tyagi

Director General
Medical and Health Services
Uttar Pradesh

With demographic transition underway in India, elderly population that suffer from dual burden of communicable and non-communicable diseases besides impairment of special sensory functions like vision and hearing and other degenerative diseases puts an immense strain on the health system. The elderly population needs specialized medical care to cope up with the multitudes of ailments especially those that require surgical intervention.

In today's various surgical fields, endoscopic therapy plays a prominent role. Numerous surgeries performed with the naked eye in the past have achieved the same or better results using an endoscope. As in other surgical departments, spine surgery has continued to strive for the use of endoscopes for treatment.

With the development of optical technology, imaging devices, and surgical instruments, and the passionate dedication of the various spine surgeons, endoscopic spine surgery (ESS) has made many advances over the past halfcentury. Minimizing damage to normal structures and effectively removing only lesions through spinal endoscopy, helps patients recover quickly and return to daily life early while relieving patients from unnecessary worries and anxiety about the sequelae of surgery. Furthermore, it encourages patients not to hesitate to choose the appropriate surgical treatment.

Through this module on Continuing Medical Education (CME) on Comprehensive Guide to Endoscopic Spine Surgery for Medical Officers in Provincial Health & Medical Services in Uttar Pradesh, State Institute of Health & Family Welfare (SIHFW), Uttar Pradesh has developed a comprehensive guidebook dedicated exclusively to providing high-quality, patient-centered care and this will aid Medical Officers in Uttar Pradesh to scale up the services delivery at their health facilities, thus benefitting communities.

With the development of this module SIHFW has established genuine links between the theory and practice of healthcare management. I wish team SIHFW the best and hope that many such customized CME modules will be published in the near future.

(Dr. Deepa Tyagi)

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MESSAGE

Dr. Brijesh Rathor

Director General
Medical Health and Family Welfare
Uttar Pradesh

Apart from age-related issues such as loss of sensory functions, elderly people are also susceptible to chronic conditions such as hypertension, coronary heart disease, cancer, orthopedic issues etc. People who are 65 years and older often have co-morbidities that influence how treatment side effects could affect them. Any surgical intervention should take into consideration the above mentioned facts and should be minimally invasive in nature.

Transforaminal endoscopy is not just a field in medical science but a patientcentered philosophy. It is a technique of care, endeavoring to alleviate the patients' back pain, sciatica, and paralysis of the legs and feet, and helping them to become, once again, a healthy person without sequelae.

In spinal surgery, safety is as important as a successful outcome. The expansion and brightening of the operation field through the endoscope help prevent posttreatment side effects such as nerve damage and bleeding. The smaller the incision and greater the magnification of the affected area with bright light, the less invasive the treatment can be, allowing for minimal damage to the patient's body while effectively treating the lesion. These advances work together towards an optimal cure with minimal scarring

This module on Continuing Medical Education (CME) on Comprehensive Guide to Endoscopic Spine Surgery for Medical Officers in Provincial Health & Medical Services in Uttar Pradesh, is an excellent guidebook for Spine Surgery that is intended to reinvent established practices along with contemporary best case study scenarios.

This module will enhance skills of Medical Officers who are posted at CHCs/PHCs in managing emergencies concerning elderly population along with providing effective medical care at the primary level.

I congratulate the faculties at State Institute of Health & Family Welfare, Uttar Pradesh and the Subject Matter Experts in developing this convergent module with a holistic view on public health.

(Dr. Brijesh Rathor)

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MESSAGE

Dr. Shailesh Kumar Srivastava

Director General (Training)
Medical Health and Family Welfare
Uttar Pradesh

As an outcome of better health care services and mortality rates there is a demographic transition happening in the country. It is expected that the number of elderly in the country would reach 324 million by the year 2050. The healthcare challenges faced by elderly in India revolved around both communicable and non-communicable diseases.

Healthcare needs of the ageing population often require surgical interventions. Considering their advance age and co-morbidities, a minimally invasive surgical approach is the need of the hour. The transforaminal approach is historically the most fundamental endoscopic approach among the endoscopic approaches ever been made.

It is the most faithful to the minimally invasive principles and has various advantages in removing lesions. The transforaminal approach utilizes the original anatomy of the spine to its fullest extent. It allows direct access to the dorsal root ganglion, the fundamental cause of low back pain and radiating pain, by directly checking the inside of the intervertebral disc, epidural space, nerve tissue, and facet joint area.

Through this module on Continuing Medical Education (CME) on Comprehensive Guide to Endoscopic Spine Surgery for Medical Officers in Provincial Health & Medical Services in Uttar Pradesh, State Institute of Health & Family Welfare, Uttar Pradesh with the help of Subject Matter Experts has provided a comprehensive, coherent and research-based insight to Endoscopic Spine Surgery.

The faculties at State Institute of Health & Family Welfare, Uttar Pradesh and the team of experts of the field have done a commendable job by publishing this module. I hope that the Medical Officers in Provincial Health & Medical Services in Uttar Pradesh will take advantage of this initiative and make the most in their field with this handy module.

(Dr. Shailesh Kumar Srivastava)

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ACKNOWLEDGEMENT

Dr. Rajaganapathy R.

Director
State Institute of Health and Family Welfare
Uttar Pradesh

Old age is a sensitive phase - elderly people need care and comfort to lead a healthy life without worries and anxiety. Lack of awareness regarding the changing behavioural patterns in elderly people leads to neglect of various issues that affect the lives of elderly people and further complicate into major physiological problems.

Degenerative spinal disorder is one of the emerging and disabling problems among the ageing population. With increasing life expectancy and rising population with diabetes mellitus and other immunocompromised diseases, spinal infection become a heavy burden to the public health system. To face such challenges, newer techniques with better outcome are demanded.

As we all know Endoscopic Spine Surgery is one of the most innovative and less invasive spine procedures. It is very promising and has the distinct advantages, such as less pain, less morbidity, quicker patient recovery and minimal surgical trauma, just to name a few.

Endoscopic Spine Surgery has opened up new horizons and perspectives in the area of spine surgery. Medical Officers in Provincial Health & Medical Services in Uttar Pradesh will gain a deeper understanding of this rapidly evolving surgical domain and will find this Continuing Medical Education module on "Comprehensive Guide to Endoscopic Spine Surgery" a necessary reading in their delivering quality care.

I acknowledge the efforts of faculties at State Institute of Health and Family Welfare, U.P. and that of the Subject Matter Experts such as Dr. Anupam Sachan from Ursula Horsman Memorial (UHM) District Hospital, Kanpur Nagar, Dr. Vineet Kumar from Dr. Ram Manohar Lohia Institute of Medical Sciences (DR.RMLIMS), Lucknow and Dr. Shah Valiullah from King George's Medical University, Lucknow in developing this important module.

I hope that this module will serve its intended purpose and enhance the capacity of Medical Officers in Provincial Health & Medical Services in Uttar Pradesh leading to improvement in clinical interventions at the grass root level.

(Dr. Rajaganapathy R.)

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Chapter -1

HISTORY OF DEVELOPMENT OF ENDOSCOPIC SPINE SURGERY

Philosophy of Minimalism in Spine Surgery with Endospine-The Mobile Tubular Retractor and evolution to Destandau -

Introduction-

Aging process produces biochemical and mechanical changes in disc and facet joint. Intervertebral disc blood supply is up to the age of 8 years. Afterward there is diffusion of fluid from the vertebral body to the disc and vice versa. The lower lumbar spine bears the burden of enormous stress, holds the person upright, and returns body even without loading, to vertical position from sitting, lying, and, especially, a bent-over position. When there is sudden compression loading, sudden rise in intradiscal pressure occurs. This rise in intradiscal pressure is partially minimized by transfer of fluid from the disc to vertebral body. Thus this tissue fluid transfer acts as a safety valve and protects the disc. The strong fibers of annulus also protect nucleus pulposus. Disc degeneration, with aging, leads to annular tear. There is associated decrease in disc height with annular bulging. There is a natural attempt to autostabilize the motion segment by forming osteophytes circumferentially, at the vertebral margins and at the attachment of annulus. Osteophyte from end plate is one of the reasons for root compression. Decrease in disc height causes decrease in cross sectional area of the neural foramen. This is one of the factors in lateral recess stenosis.

Facet joint in the spine is an arthrodial joint, which permits only gliding movement at the joint. Lax capsule of the joint is reinforced by ligamentum flavum anteriorly and supraspinatus ligament posteriorly. Strong annulus prevents movements at the joint. When the annular fibers degenerate with aging and mechanical stress, excessive play at these joints is permitted. Hence degenerative changes in the disc make the facet joints more vulnerable to strain. Excessive play at the facet leads to facet erosion with loss of cartilage, adding to capsular laxity. Natural process of autostabilization at the facet joint leads to facet hypetrophy. Medial border of superior articular process develops osteophytes compressing nerve root in latera lrecess . Degenerative changes

in spine due to aging lead to compression of neural structures. In absence of instability the main principle of spine surgery in degenerative compressive neural pathology is decompression of compressed neural structures.

"lt really does not matter what technique you use to decompress the nerve root, if you fail

to fully decompress the nerve root or introduce complications to the equation, you have

failed to serve the patient." lan MacNab

Tubular retractors -

Aim of minimalism in spine surgery is to minimize the approach-related trauma, while preserving the stability. First step in minimalism in spine surgery is use of tubular retractor. First description of microsurgical discectomy procedure was published in 1977, the use of tubular retractor was thought of by Dr Casper in 1977. It was Dr Williams, a neurosurgeon and consultant of many casinos in Las Vegas employing female dancers, who popularized the technique in the United States. The popularity was due to its use of smaller incisions which allowed the performers to return to dancing more quickly after the procedure. Perhaps the quality of microscopic vision through tubular retractor has not helped the surgeon continue using tubular retractor in lumbar discectomy and minimalism progressed to **Destandau technique,** however after introdution of Microscope vision improved and this technique is used by most of the nurosurgeon and called as Tubular endoscopy or microsurgical discectomy.

Destandau technique –

In Destandau's Technique the surgeon uses Endospine, a set of outer tube/insert and inner tube/working insert with an endoscope. The endoscope used with Endospine is 18-cm-long, rigid, straight,O-degree endoscope.lt is an universal endoscope used in cystoscopy, arthroscopy, and sinoscopy, etc. The outer tube is elliptical in shape rather than circular. Endospine was initially used for lumbar disc herniation. The target area in the lumbar region is elliptical, in between two laminae, medially the spinous process and laterally the medial facet. Hence the outer tube is elliptical. The inner tube/working insert fits into the outer tube with a tightening screw or a rachet type lock. There is an inherent telescoping movement in between these tubes.

The working insert has four in-built channels inside. The channels for endoscope and suction are at an angle of 12 degrees to the wide channel for instrument. Because of this angle, we can use 0 degree endoscope as an angled endoscope. This helps in minimizing the fogging of endoscope tip. When the endoscope and the instrument work parallel to each other, there is intermingling of the instruments.In addition, the surgeon has to use an angled endoscope when endoscope and instrument work parallel to each other. The fourth channel is for nerve root retracter. Via this method vision improved but this is dry endoscopy and soiling of endoscope tip hamperd the vision.

Evolution of Endospine duo – The endospine duo system has been developed to reduce the size of skin incision however indications are identical and incision size reduced from 29 mm to 23.5 mm.

Evolution of arthrospine duo – Arthrospine duo is similar to endospine duo however in this after entering in canal saline medium can be used, this improves vision. However incision remains same.

In search of reducing incision size leads to development of true endospine.

History of development of endoscopic spine surgery -

Degenerative spinal disorder is one of the emerging and disabling problems among the ageing population. With increasing life expectancy and rising population with diabetes mellitus and other immunocompromised diseases, spinal infection become a heavy burden to the public health system. To face such challenges, newer techniques with better outcome are demanded. As we all know Endoscopic Spine Surgery is one of the most innovative and less invasive spine procedures. It is very promising and has the distinct advantages, such as less pain, less morbidity, quicker patient recovery and minimal surgical trauma, just to name a few.

Endoscopic Spine Surgery has opened up new horizons and perspectives in the area of spine surgery., those who intend to gain a deeper understanding of this rapidly evolving surgical domain, will find this ***module*** **a** necessary reading in their professional journey.

In today's various surgical fields, endoscopic therapy plays a prominent role. Numerous surgeries performed with the naked eye in the past have achieved the same or better results using an endoscope. As in other surgical departments, spine surgery has continued to strive for the use of endoscopes for treatment. With the development

of optical technology, imaging devices, and surgical instruments, and the passionate dedication of the various spine surgeons, endoscopic spine surgery (ESS) has made many advances over the past half-century. Minimizing damage to normal structures and effectively removing only lesions through spinal endoscopy helps patients recover quickly and return to daily life early while relieving patients from unnecessary worries and anxiety about the sequelae of surgery. Furthermore, it encourages patients not to hesitate to choose the appropriate surgical treatment.

The transforaminal approach is historically the most fundamental endoscopic approach among the endoscopic approaches ever been made. It is the most faithful to the minimally invasive principles and has various advantages in removing lesions. The transforaminal approach utilizes the original anatomy of the spine to its fullest extent. It allows direct access to the dorsal root ganglion, the fundamental cause of low back pain and radiating pain, by directly checking the inside of the intervertebral disc, epidural space, nerve tissue, and facet joint area.

Transforaminal endoscopy is not just a field in medical science but a patient-centered philosophy. It is a technique of care, endeavoring to alleviate the patients' back pain, sciatica, and paralysis of the legs and feet, and helping them to become, once again, a healthy person without sequelae. Surgery consisting of big skin incisions and bone cutting can be devastating to patients. If surgeons treat their patients the way they would treat their own body or those of their family, they would shy away from destructive incisional surgeries. After the procedure, patients should be able to return to their work and study as soon as possible. Therefore, surgeons should focus not only on the problem at hand but also on the patient's life and daily routine to follow.

In spinal surgery, safety is as important as a successful outcome. The expansion and brightening of the operation field through the endoscope help prevent post-treatment side effects such as nerve damage and bleeding. The smaller the incision and greater the magnification of the affected area with bright light, the less invasive the treatment can be, allowing for minimal damage to the patient's body while effectively treating the lesion. These advances work together towards an optimal cure with minimal scarring.

In addition, as transforaminal endoscopy does not require general anesthesia, patients tend to experience less anxiety compared to open surgery. Patients with chronic diseases such as diabetes, heart disease, kidney failure, and stroke, as well as older

patients, can be treated with this technique. Since it is performed with the patient under conscious sedation, the patient can communicate with the surgeon and feel the resolving pain and numbness right after the procedure.

A typical endoscopic lumbar disc herniation procedure performed by a spine specialist takes about 20-30 min. The patient experiences immediate improvement after the procedure and can be discharged on the same day. Since the lesion is approached directly, the typical scar is less than 1 cm in length.

Patients with spinal stenosis also show improvement in less than a day after transforaminal endoscopy. The procedure has a small skin incision and brings fast patient recovery since there is minimal damage to the normal tissue.

The Invention of the Transforaminal Approach (Before the 1990s)

Before endoscopic treatment was invented, there have been attempts to percutaneously examine spinal lesions and treat them nonsurgically using a posterolateral approach such as percutaneous biopsy, discography, and chemonucleolysis. However, after Parviz Kambin's achievements, proper percutaneous surgical treatment of intervertebral disc was possible. Confirming the concept of an accessible, reproducible, and neurologically safer corridor was a monumental event in the history of endoscopic spinal surgery (ESS).

Open discectomy following laminectomy was the standard treatment for disc herniation before and long after Kambin. The surgery was performed using a midline or paramedian approach. It required damage to paraspinal muscles, laminar, and facet joint structures to secure a field of view to identify and remove the herniated intervertebral discs. *In addition, acceleration of disc degeneration by removing the nucleus pulposus was a common concern of spine surgeons performing open disc surgery* . In particular, spine surgery in historically earlier periods targeted patients with more severely degenerated diseases. In contrast, later spine surgery targeted more patients who only complained of pain and did not develop severe neurological deficits. It was essential to have an operation that caused as few sequelae as possible.

Several spine surgeons have studied alternative surgical methods that avoid the midline or paramedian approach. In 1951, Hult reported a nucleotomy using an anterolateral abdominal extraperitoneal approach . In 1975, Hijikata performed nonvisualized percutaneous nucleotomy using a posterolateral approach .

Kambin and his colleagues have studied methods and devices to reach the posterior surface of an intervertebral disc through a posterolateral approach since the mid-1970s. He performed the first percutaneous decompression of an intervertebral disc using the Craig cannula in 1973 , In 1982, he performed percutaneous posterolateral discectomy on nine patients and reported the results of suctioning fragments from the dorsal portion of the discs using high negative pressure. Kambin's research and experience of the posterolateral approach without passing through the central spinal canal led to the first description of "the triangular working zone" in 1988 , It inspired many pioneering spine surgeons to develop new surgical treatments. For spine surgeons seeking new treatments, discovering a safe passage to the intervertebral disc **was like Vasco da Gama's discovery of the sea route to India.**

Dr. Parviz Kambin

The Beginning of the Endoscopic Spine Surgery (the 1990s) -

ESS began in the 1990s. After Parviz Kambin reported on a "safe triangular working zone" on the verge of the 1990s, with the addition of advances in surgical instruments and imaging devices, ESS was finally realized. Early in the history of ESS, the primary attention was focused on the intervertebral disc.

Before introducing ESS, percutaneous treatment for intervertebral discs was a blind method rather than directly viewing a fragmented disc. It was an indirect method of decompression of the center of the intervertebral disc. In 1985 Onik performed automated percutaneous nucleotomy , After crushing the inside of the nucleus pulposus by a mechanical method, they were washed with saline. It was difficult to expect a high success rate due to limited indications. Still, it was an alternative treatment modality that provided a percutaneous surgical method without anaphylaxis, which was the significant side effect of chemonucleolysis.

The most significant advantage of endoscopic surgery is that lesions can be treated while closely visualizing in the surgical field. It was needed to differentiate between lesions and normal tissues to achieve the goal.

As the experience of percutaneous treatment has been accumulated, several ideas have been reported that can lead to the birth of percutaneous endoscopic disc surgery around 1990. Kambin reported intraoperative discoscopic views of herniated nucleus pulposus (HNP) in 1988 , and Schribcr in 1989 injected indigo carmine, which can stain a normal nucleus and annular fissure into an intervertebral disc.

In 1991 Leu and Karl Storz developed a foraminoscope. Their method, called "discoscopy," introduced an arthroscope from the contralateral side of the lesion, allowing direct visualization of intradiscal operative procedures. Leu's foraminoscope contributed to the development of early endoscopy for a long time.

Mayer and Brock first used the term "percutaneous endoscopic lumbar discectomy(PELD)" in 1993 , They used a bilateral biportal approach, similar to the Leu method. They removed the intervertebral disc fragments using an automated nucleotome and rigid or flexible forceps while observing the posterior aspect of the fibrous annulus inside the intervertebral disc.

A method of treating the ipsilateral side of the lesion using an endoscope and surgical instruments like the current transforaminal ESS was reported in 1996. Mathews in 1996 and Ditsworth in 1998 performed transforaminal ESS using a working channel scope . In 1996, Kambin and Zhou also reported transforaminal arthroscopic decompression of lateral recess stenosis , From these, transforaminal ESS was initiated.

SH Lee reported his experiences of the percutaneous endoscopic manual and laser discectomy at the 19th SICOT World Congress in 1993. He published the result in the *Orthopade,* a surgical journal in Germany, in 1996 . He established the concept of "intraannular subligamentous fragmentectomy" using Ho: YAG laser. With Martin Knight and Anthony Yeung, SH Lee was invited to the American Minimally Invasive Surgery Conference in 2000 and presented his surgical method. He frequently cooperated with Kambin from the beginning and devoted his whole life to expanding ESS fundamentals worldwide .

Dr. Parviz Kambin with Dr. S.H. Lee

Development of Endoscopic Spine Surgery (Since 2000) In the 2000s, two important endoscopic techniques by Anthony Yeung and Thomas Hoogland were reported .In 2002, Yeung and Tsou reported an endoscopic disc surgery using a rigid rod-lens, integrated, multichannel, and wide-angled endoscope. Anthony Yeung's surgical method was known as the "inside-out" technique due to the starting position being the inside of the discs. He developed the Yeung Endoscopic Spine System (YESS) with Wolf Company of Illinois .

Dr. Anthony yeung

Dr. Thomas Hoogland

In 2005, Schubert and Thomas Hoogland reported a surgical technique using the Thomas Hoogland Endoscopic Spine System (THESS YS). They performed foraminoplasty using a specialized reamer before removing disc particles, so their surgical method was known as the "outside-in" technique.

The two methods have become the most famous endoscopic techniques soon. Many doctors have reproduced their surgical procedures. Each method has strengths in treating prolapsed intervertebral discs through the inside of the intervertebral disc (YESS) and resolution of foraminal stenosis through foraminoplasty (THESSYS).

Spine doctors in korea at WSH, including SH Lee, used the “half-and-half’ technique that improved the “inside-out” technique . This method was a way to see the inside of the intervertebral disc with half of the field of view and the epidural space with the other half of the field of view . Since 2000, ESS has gradually expanded the scope of decompression surgery. In 2004, Ahn et al. of the WSH group reported the usefulness of ESS for the treatment of recurrent HNP (Herniated nucleus pulposus) In 2008, the same group, Choi et al., reported that highly migrated intracanal disc herniations could be treated using a foraminoplastic technique using a rigid working channel endoscope

In addition, transforaminal approach methods have also become more diverse. In 2005, Rutten reported a technique called full endoscopy through extreme lateral access to overcome the usual transforaminal approach, which is associated with problems in reaching the epidural space directly with unhindered vision.

Transforaminal ESS has been further developed. The decompression range is now available in various types of HNP, including low and highgrade migrated HNP, huge central HNP, calcified or hard HNP, foraminal HNP, extraforaminal HNP, and recurrent HNP. *It also can treat foraminal and lateral recess stenosis.*

Since the mid 2010s, transforaminal endoscopic fusion surgery has also been reported .

In 2018, the U.S. government and academic societies approved medical insurance coverage for endoscopic disc treatment, which Kambin and Leu initiated with the International Society of Minimally Invasive Spinal Surgery (ISMISS). At the University of Miami Hospital and the training hospitals of Yale School of Medicine, ***endoscopic surgery was included in the regular spine doctor training program.*** In 2019, the North American Spine Society also had this surgery in the formal educational program.

Summary -

Based on the advances in optical technology, imaging devices, surgical instruments, and the passionate dedication of many spine surgeons, ESS has made much progress. Only a limited portion of the prolapsed intervertebral disc inside the spinal canal could be removed in the earlier period of ESS.

For the past half century, ESS has expanded its indications to treat a broader range of diseases. The transforaminal approach is the most fundamental approach for

endoscopic treatment and is most faithful to the minimally invasive principle. It is possible to solve the pain caused by compressive lesions inside and outside the intervertebral foramen. The ESS removes the cause of the disease without tissue damage, helps the patient recover quickly and return early, and encourages the patient to receive the necessary treatment in time without sequelae. It is an approved treatment recognized by the U.S. government, academic societies, and medical training institutes. .

Recently, the new concept of spine surgeries has been introduced such as virtual reality, biomaterials, robotics, navigation, and endoscopic surgery. In my opinion the mainstream of minimally invasive spine surgery will be endoscopic spine surgeries***. In the present, endoscopic spine surgeries have been vigorously developed, and indications of endoscopic spine surgeries have been extended from disc herniation to stenosis and instability and from lumbosacral to cervical area.***

Introduction & evolution of endoscopic spine surgery in india –

Dr. satishchandra gore from india worked with Dr. Anthony yeung and published several papers with them and establishes Inside-out technique and Pioneer of Endoscopic spine surgery in india. Dr. Girish datar from Miraj Maharashtra also worked with Dr. Gore and Dr. yeung and Trained several surgeons in Endospine.

Dr. S.C. Gore

Dr. Girish Datar

Generations of Endoscopic Spine Surgery -

Full endoscopic transforaminal approaches were firstly tried for lumbar disc herniation without bone work . This is the ***first generation*** of endoscopic spine surgery of lumbar lesion. ***Second generation*** of endoscopic spine surgery is the posterior interlaminar approach without bone work for the removal of rupture disc herniation of lumbosacral area. After trial of posterior interlaminar approach, it was able to perform posterior endoscopic decompressive procedures including laminectomy and laminotomy. New endoscopic specialized instruments such as endoscopic drill systems, reaming systems

of foraminoplasty, and endoscopic Kerrison rongeur were developed. As a result, endoscopic decompressive laminectomy, endoscopic laminotomy, lateral foraminotomy (paraspinal approach), and foraminoplasty were possible. *Therefore, indications of endoscopic surgeries have been extended from disc herniation to lumbar central stenosis and foraminal stenosis.*

Also, modified interlaminar endoscopic systems with a large working channel was developed for the treatment of lumbar stenosis. And biportal endoscopic surgeries have been reemerged and developed in South Korea. Now, lumbar stenosis is able to be fully decompressed by large working channel interlaminar endoscopic systems or bi portal endoscopic approaches , ***The third generation*** of endoscopic spine surgery is endoscopic decompressive procedure for lumbar stenotic lesion by uniportal or biportal . Especially, compared to uniportal endoscopic approach, biportal endoscopic surgery has different characteristics; there were two portals including endoscopic channel and working channel. Biportal endoscopic surgery was well known as abbreviation name of UBE (unilateral biportal endoscopy) in South Korea. This biportal endoscopic approach was advantage of decompressive surgical procedure .

Another recent issue of endoscopic spine surgery may be endoscopic lumbar interbody fusion ***fourth generation*** . There were three approaches of endoscopic lumbar interbody fusion: first is the trans-Kambin triangle approach, second is the endoscopy-assisted transforaminal lumbar interbody fusion, and third is the endoscopy-assisted lteral lumbar interbody fusion . Although early clinical results of endoscopic lumbar interbody fusion surgeries may be relatively favorable, we need to investigate long-term outcome and comparative study

The paradigm of endoscopic spine surgeries is still moving, and surgical techniques and instruments of endoscopic spine surgeries are still developing. Finally, the boundary and indication? between conventional surgery and endoscopic surgery seem to be narrow or to disappear. We should make an effort to learn a new technique of endoscopic spine surgeries .

Generation of endoscopic spine surgery in lumbar lesion

	1 st generation	2nd generation	3rd generation	4th generation
Endoscopy systems	Uniportal	Uniportal	Uniportal and biportal	Uniportal and biportal
Approach	Transforaminal approach	Interlaminar approach	Endoscopic laminectomy Endoscopic foraminotomy	Endoscopic lumbar interbody fusion
Indications	Lumbar disc herniation	Lumbar disc herniation	Central or lateral recess stenosis Foraminal stenosis	Spondylolisthesis Instability Combined lesion

Chapter -2

NOMENCLATURE OF ENDOSCOPIC SPINE SURGY

Nomenclature of Endoscopic Spine Surgery –

Endoscopic spine surgery was introduced a few decades ago and has rapidly progressed since then, owing to the development of various types of drills and instruments (scope, punch, and dissector). Besides, highly skilled surgeons have created a variety of endoscopic surgical methods. Even though the overall history of endoscopic spine surgery is quite long, the procedure has various names, causing a lack of standard terminology in the literature and spinal societies. It has also disturbed the communication of concerns between surgeons, patients, and hospitals.

To date, international community meetings have not yet defined nomenclature for endoscopic spine procedures.

AOSpine minimally invasive spine surgery curriculum task force (MISTFT) suggested nomenclature.

The previously utilized nomenclature was searched and compared with each other, and the outcomes of surgery were analyzed. *It was integrated into a systematic nomenclature system: (1) approach corridor, (2) mode of visualization, (3) spinal segment, and (4) type of procedure. Then, a new nomenclature was proposed with the above system.*

term ***"full endoscopic"*** is used to describe procedures performed with a working channel endoscope, which is different from endoscopic-assisted surgery that requires another pathway for the surgical working procedure eg.- (UBE).

The working channel endoscopy should have the four components in one scope: (I) irrigation channel, (2) working channel, (3) optic (a rod-lens system), and (4) illumination (xenon light)

Understanding and Unifying the Nomenclature -

This uniform system is divided into four parts as follows:

(1) approach corridor (anterior, posterior, interlaminar, and transforaminal),

(2) visualization of the lesion (endoscopic),

(3) segment (cervical, thoracic, and lumbar), and

(4) procedure (discectomy, foraminotomy, and decompression).

It is named in the following order: working channel endoscopy (full endoscopic), approach corridor (anterior, posterior, interlaminar, transforaminal), spinal segment (cervical, thoracic, and lumbar), and procedure performed (discectomy and foraminotomy, lateral recess decompression, and unilateral laminotomy for bilateral decompression).

The spine segment is classified as cervical, thoracic, and lumbar. The procedures include discectomy, foraminotomy, lateral recess decompression, and unilateral laminotomy and bilateral decompression.

Most commonly used terms are-

Full endoscopic surgery-

Posterior Endoscopic Cervical Discectomy (PECD) or Foraminotomy (PECF) -

Traditionally, this procedure was termed “posterior cervical laminoforaminotomy” or “cervical foraminotomy” or “keyhole foraminotomy”. Ruetten and colleagues initially introduced this procedure . It was published under various names in the paper. The purpose of this procedure is direct visualization and decompression of the exiting nerve root from its origin to the lateral margin of the caudal pedicle. In the literature, it is called “full-endoscopic posterior ***cervical*** foraminotomy” (FPCF)

Transforaminal Endoscopic Lumbar Discectomy (TELD) -

The approach to the disc through the “triangle of Kambin” is the beginning of endoscopic surgery. With this safe entry pass way, Yeung developed YESS endoscopy and related equipment. It makes safe and efficient pathologic disc removal. The goal of this procedure is resection of any disc herniation by visualizing the segmentally decompressed nerve roots. In the literature IT IS CALLED AS, arthroscopic microdiscectomy, minimally invasive disc surgery, posterolateral endoscopic excision for lumbar disc herniation, transforaminal posterolateral endoscopic discectomy.

Interlaminar Endoscopic Lumbar Discectomy (IELD)

The traditional approach window for resection of any disc herniation and visualization of decompressed nerve roots is the interlaminar space. The interlaminar area was used from the era of classic open surgery until tubular, microscopic surgery. The first endoscopic trial for this window was the interlaminar endoscopic discectomy of L5/S1. In the literature IT IS CALLED AS full-endoscopic interlaminar access (FEIL) , full-endoscopic interlaminar approach (FEIA) , interlaminar access (ILA) for percutaneous endoscopic lumbar discectomy.

Lumbar Endoscopic Unilateral Laminotomy for Bilateral Decompression (LE-ULBD)

Unilateral approach bilateral decompression (ULBD) is a safe and efficacious treatment option for spinal stenosis . Compared to conventional open surgery, endoscopic surgery has similar treatment outcomes . The visualized field during an endoscopic procedure is wider than open surgery with the help of the variable angle of the scope lens.

In the future, this factor may lead to less injury of the facet joint complex compared to conventional surgery. Acute postoperative back pain after endoscopic surgery may be less than that in open surgery. Additionally, the duration of hospital stay may be reduced.

The goal of this procedure is complete central and lateral recess decompression of the neural elements spanning from the tip of the SAP to the midportion of the caudal pedicle. They suggested the term “lumbar endoscopic unilateral laminotomy for bilateral decompression” (LE-ULBD).

In the literature, the terms such as full-endoscopic bilateral interlaminar technique , full- endoscopic lumbar laminectomy, and percutaneous endoscopic laminotomy with flavectomy by a uniportal and unilateral approach have been used

Endoscopic-Assisted Surgery -

Unilateral Biportal Endoscopic (UBE) Surgery -

In the field of endoscopic spine surgery , Unilateral biportal endoscopic surgery (UBE) has been described as one of the endoscopy- assisted surgeries with MED, MEL, and Destandau. UBE or biportal endoscopic spine surgery (BESS), which has

two portals (one for the lens and the other for the operative instrument), is growing in number. UBE is familiar for surgeons who can perform open microscopic spine surgery. Hence, various names have been used for these procedures. Historically, UBE was conceived as a translaminar lumbar epidural endoscopy procedure in 1996 and 1998 in the Arthroscopy journal by Dr. De Antoni.

Three years later, a team of Korean spine surgeons, including JH Eum, DW Heo, and SK Son, who have been pioneers of this surgery, suggested endoscopy for lumbar stenosis, which was described by the name of UBE. Almost simultaneously, DJ Choi introduced the term, BESS, in 2016 .

Knowledge of spine anatomy, the spinal bone, and the spinal column is fundamental in the performance of endoscopic spine surgery. The success of full endoscopic spine surgery is the understanding of its safe and danger zones so that intraoperative complications such as neural structural problems may be avoided.

Chapter -3

ENDOSCOPIC SPINE ANATOMY

Adult Spine Anatomy-

The vertebral body and arch are the two main components of a typical vertebra. The vertebral arch is posterior. These two components include the vertebral foramen, which contains the spinal cord. The sacrum and coccyx may not have a central foramen, because the spinal cord terminates in the lumbar spine. A pair of pedicles and laminae comprises the vertebral arch, which supports seven processes: four articular, two transverse, and one spinous, also known as the neural spine. The vertebral foramen is surrounded by two transverse processes and one spinous process. The spinous process originates from the posterior, one transverse process originates from the left, and the other transverse process originates from the right. Throughout the dermis, spinous processes of the cervical and lumbar regions can be observed. Facet joints are located above and below each vertebra. The pars interarticularis, a narrow part of the neural arch, is linked together, restricting the feasible range of movement . The intervertebral foramina are two small holes located between every pair of vertebrae and where all the spinal nerves enter the spinal cord.

SPINE CONSISTS OF FOLLOWING BONES

1. Cervical spine (C1-C7): Seven vertebrae
2. *Thoracic spine (T1-T12): Twelve vertebrae*
3. *Lumbar spine (L1-L5): Five vertebrae*
4. *Sacrum (S1-S5): Five vertebrae (fused)*
5. *Coccyx (Tailbone): Three to five vertebrae* (fused)

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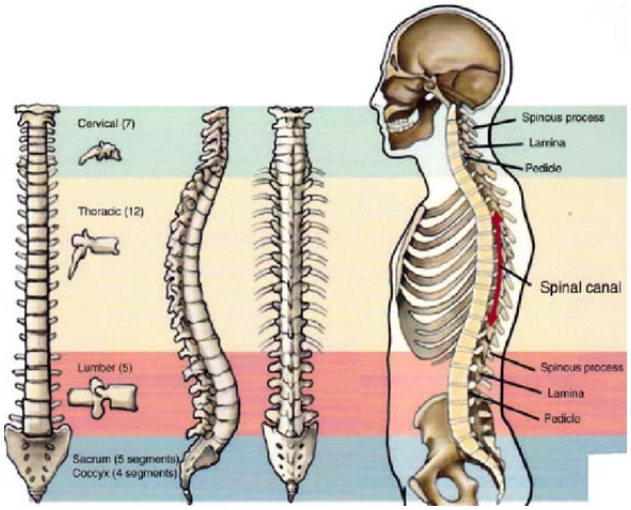


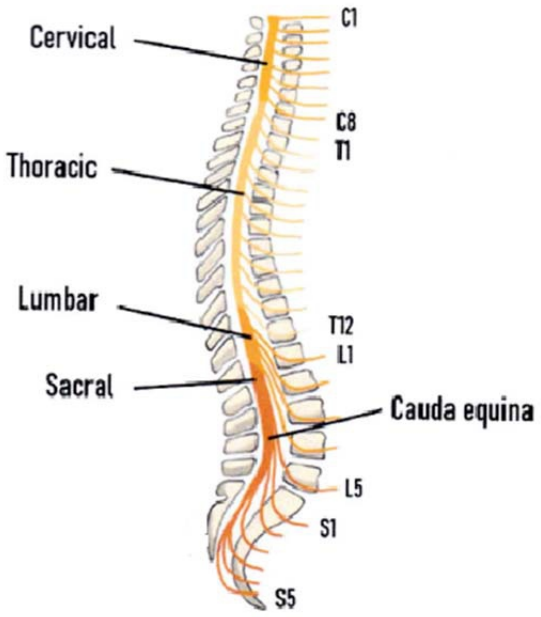
Blood Supply

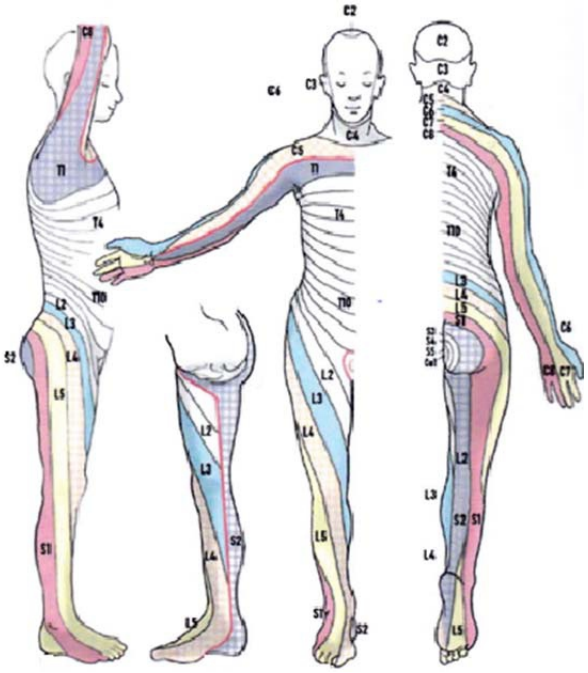
Depending on the region, vertebral blood supply to the spinal cord originates from a variety of sources across the bodv .The single anterior spinal artery (ASA) and two posterior spinal arteries (PSAs) provide the spinal cord with most its blood flow. The ASA supplies blood to the anterior 2/3 the spinal cord, which includes both lateral and ventral corticospinal tracts.The dorsal sensory columns receive blood from the PSA.

Spinal Nerve

The spinal nerve is a mixed neuron that connects the spinal cord to the body, carrying motor, sensory, and autonomic data. Each side of the vertebral column contains 31 spinal nerve pairs . The cervical, thoracic, lumbar, sacral, and coccygeal portions of the spine are divided into sections. There were 8 pairs of cervical nerves, 12 pairs of thoracic nerves, 5 pairs of lumbar nerves, 5 pairs of sacral nerves, and 1 pair of coccygeal nerves. The spinal nerves are part of the peripheral nervous system.

The dermatome is a region of the skin that is supplied mostly by a single spinal nerve. There are 8 cervical nerves (except Cl, which has no dermatome), 12 thoracic nerves, 5 lumbar nerves, and 5 sacral nerves. Each spinal nerve transfers sensations from a specific body segment to the brain. Nerves extending from the skin of the neck are supplied by C2 through C4, arms are supplied by C5 through Tl, the chest and abdomen are supplied by T2 to L2, legs are supplied by L3 to S1, and the groin area is supplied by S1 to S4 .





Deep tendon reflexes - Also known as muscular stretch reflexes, are an important aspect of neurological examination. The stretch reflex is a muscle's reflexive reaction to the passive stretching of the tendon percussion. Although the response includes both sensory and motor components, deep tendon reflex testing is generally used to examine the health of the motor system . This response sends information to the upper and lower motor neurons in the brain. The fast stretch of the muscle-tendon unit activates the muscle spindle receptors, which enhances the firing of la afferents from the spindles in their most basic form. *Nerve motor function and deep tendon reflex testing, have high specificity and moderate to strong positivity rate of representing the abnormal spinal cord lesions*

Cervical Spine Anatomy -

Nerves, muscles, arteries, veins, vertebrae, lymphatics, glands, esophagus, and trachea are all

essential structures of the cervical spine. The cervical spine is considered a vulnerable zone because of these vital structures and the lack of bone protection. The carotid arteries are the dominant arterial blood supply for the head and neck, while the jugular veins are the major venous drainage. The cervical spine structure is complex and include the Cl (atlas), C2 (axis), and C3-C7 (subaxial of the cervical spine).

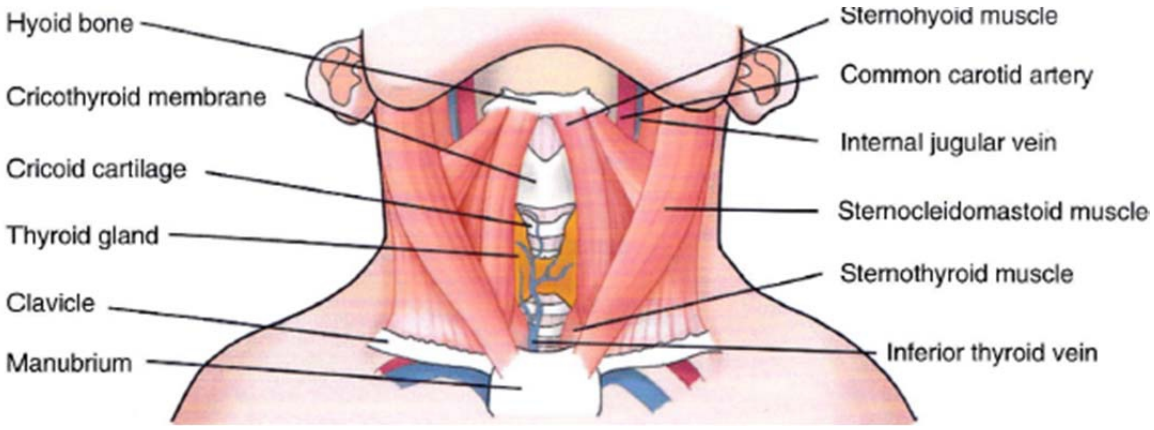
C1 (Atlas) - The vertebral body of Cl (atlas) is absent, and the laminae has a thin anterior and posterior arch. . Lateral masses with superior (atlantooccipital) and inferior (atlantoaxial) articular facets are also observed in Cl. The transverse foraminal grooves for the vertebral arteries entering the foramen magnum are absent in Cl.

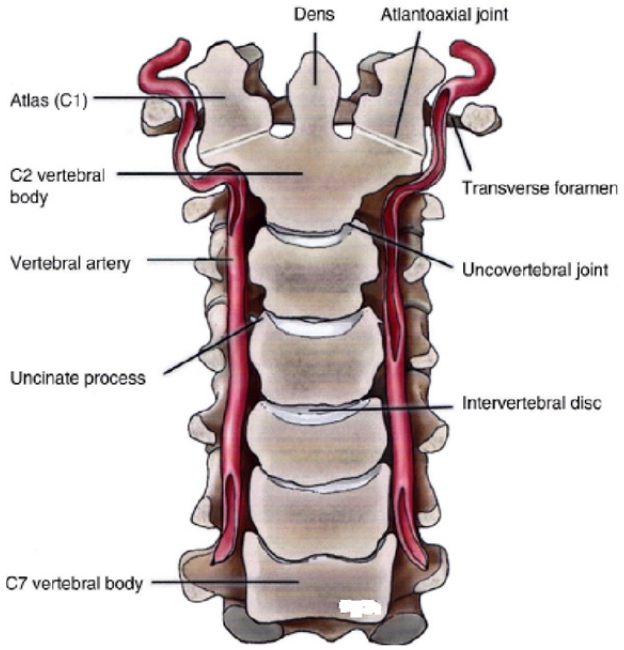
C2 (Axis) - C2 is the cervical vertebra with the highest strength. The dens or odontoid process in the C2 body represents the development from the Cl body. The posterior process of C2 is bifid with a broad lamina.

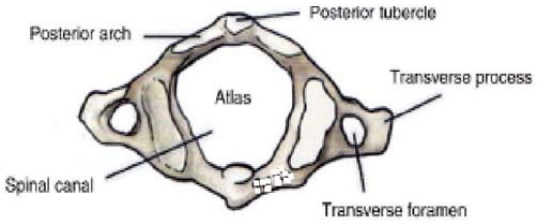
C3-C7 (Subaxial Cervical Spine) - The subaxial portion of the cervical spine is large with bifid spinous processes and upward-cupped bodies. Cervical vertebrae C6 and C7 have the longest spines. Cervical motion, including flexion, extension, and lateral bending, is constrained by the superior and inferior articular facets. The sub- axial cervical spine has a special joint, called the uncovertebral joint.*In full endoscopic surgery, the subaxial region of the cervical spine is where most surgeries are performed by cervical spine surgeons. The subaxial cervical spine is where most degenerative changes (cervical degenerative herniated disc disease), infections, or traumatic injuries occur due to high mobility . This region provides for a straightforward insertion in an anterior full endoscopic approach, allowing for a minimally invasive surgery.*

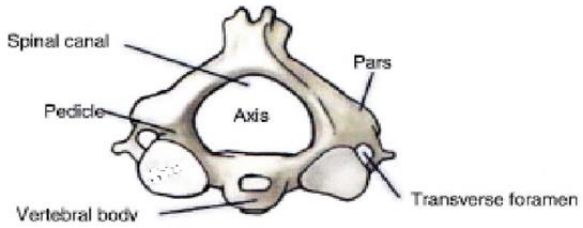
Anterior Cervical Spine Anatomy-

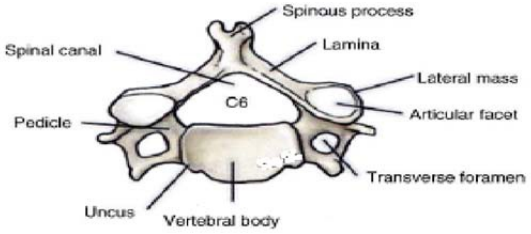
The three layers of the neck that must be thoroughly understood during applied surgical dissection are as follows: (1) The superficial layers, including the platysma; (2) The middle layers, including the sternocleidomastoid and strap muscles; and (3) The deep layers, including the left longus colli and right longus colli muscles.











Application of Anterior Full Endoscopic Cervical Discectomy –

In properly selected cases, anterior full endoscopic cervical discectomy is an effective, minimally invasive surgery for soft cervical disc herniation; however, anterior cervical discectomy and fusion is the current gold standard , Anterior endoscopic cervical discectomy is based on the principles of the anterior cervical approach (Smith-Robinson approach). Finger pressure is used to push the trachea medially while retaining the carotid sheath laterally. A sequential dilation procedure is used with a needle to approach the final working sheath through the safe working zone. The annular anchorage is released by using the side firing or laser radiofrequency dissector.

Selective cervical discectomy is performed under direct endoscopic visualization to preserve the central nucleus. It is essential to routinely check the location of the instruments for both anteroposterior and lateral fluoroscopic imaging. Instrument

placement for foraminal herniations is viewed using oblique projection via fluoroscopy. The most typical method for removing disc material is fragmentation. Tissue herniating into the canal can rupture the posterior longitudinal ligament, which can be retrieved using micropunch or grasping forceps.

Interlaminar Area of Posterior Cervical Spine -

The interlaminar space is the most frequently used space in posterior spine surgery. In full endoscopic approach, the scope is directed upward into the posterior spine and between the upper and lower laminae in the interlaminar space. The lamina is a bony ring running around the back of the vertebral body. The transition of the laminae into the articular processes forms a "V"-shaped morphology that is clearly visible, making it a helpful bony landmark for the posterior cervical procedures.

Application of Posterior Full Endoscopic Cervical Discectomy/ Laminoforaminotomy -

The full endoscopic percutaneous laminoforaminotomy or discectomy reduces paraspinal soft tissue morbidity and improves the safety of the neural structures. Unilateral cervical radiculopathies caused by a foraminal disc or bony spurs protruding into the foramen have been extensively treated with posterior cervical foraminotomy.

Thoracic Spine Anatomy –

Specific Characteristic Features - The thoracic vertebrae are generally distinguished from the other vertebrae ***by four characteristics***:

the thoracic vertebra has a heart-shaped vertebral body with demi facets (T2-T9) articulated with the heads of the ribs.

T l-T l0 has transverse processes with costal facets, which articulate with the rib tubercles.

Spinous processes are lone and slanted inferiorly.

Coostovertebral joint consists : the head of the rib articulating with the superior costal facet, inferior costal facet, and intervertebral disc .

In the atypical vertebrae of the thoracic spine, the superior facet of the T1 vertebra is not a demi-facet, because it is the only vertebra that articulates with the first rib.

T10 is articulated by a single pair of complete facets. Both the vertebral body and pedicle are covered with facets. The pedicles. T11 and T12, each have a single pair of complete costal facets.

Role of the Thoracic Nerve –

T1 and T2 supplies the apex of the chest as well as the arm and hand.

T3, T4. and T5 supplies the chest wall and controlled breathing.

T6, T7, and T8 supplies the chest and abdomen.

T9, T10, T11, and T12 supplies the abdomen and/or lower of posterior thoracic area.

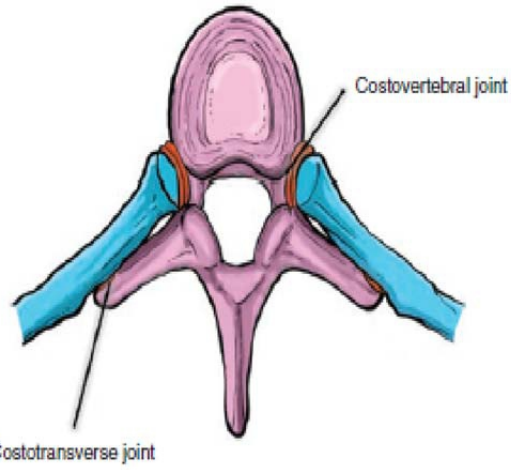
Relevant Anatomy - The relations of the thoracic spine with its surrounding structures, including the aorta, azygous vein, sympathetic chain, artery of Adamkiewicz, and diaphragm, are clinically important.

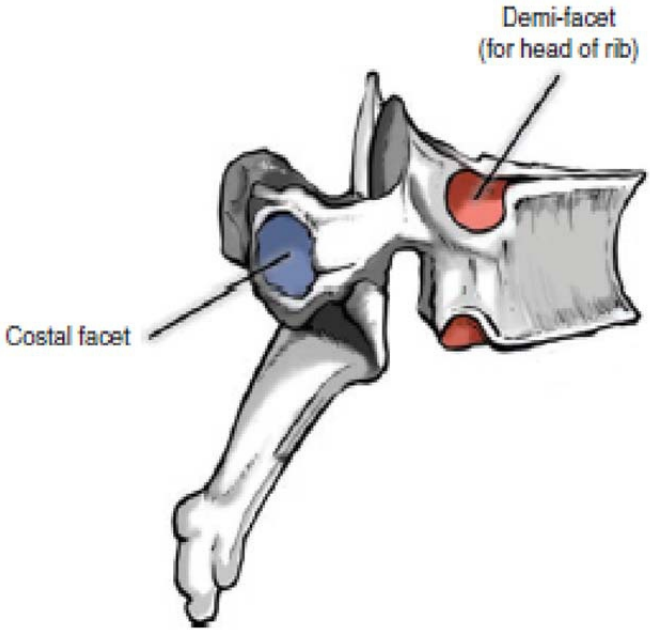
Level T3-T7: The aorta covers the left side of the spine Level T4-T5: The azygous vein crosses the lateral spinal column.

Level T1-T12: Sympathetic chain on both sides

Level T12-L1: Crus of diaphragm

Variable level: Artery of Adamkiewicz





Application of Posterior Full Endoscopic Thoracic Discectomy-

Traditionally, either transpedicular or transthoracic techniques have been used to treat thoracic disc herniations , By allowing access to the spinal canal ventral to the spinal cord without the requirement for facet joint/pedicle removal or thoracic cavity access, the endoscopic transforaminal technique significantly reduces the invasiveness of the procedure. The approach angle is limited because of the thoracic spine structure and adjacent ribs; however, by optimizing the skin incision and conducting foraminoplasty, access to the complete length of the spinal canal ventral to the spinal cord can be established.

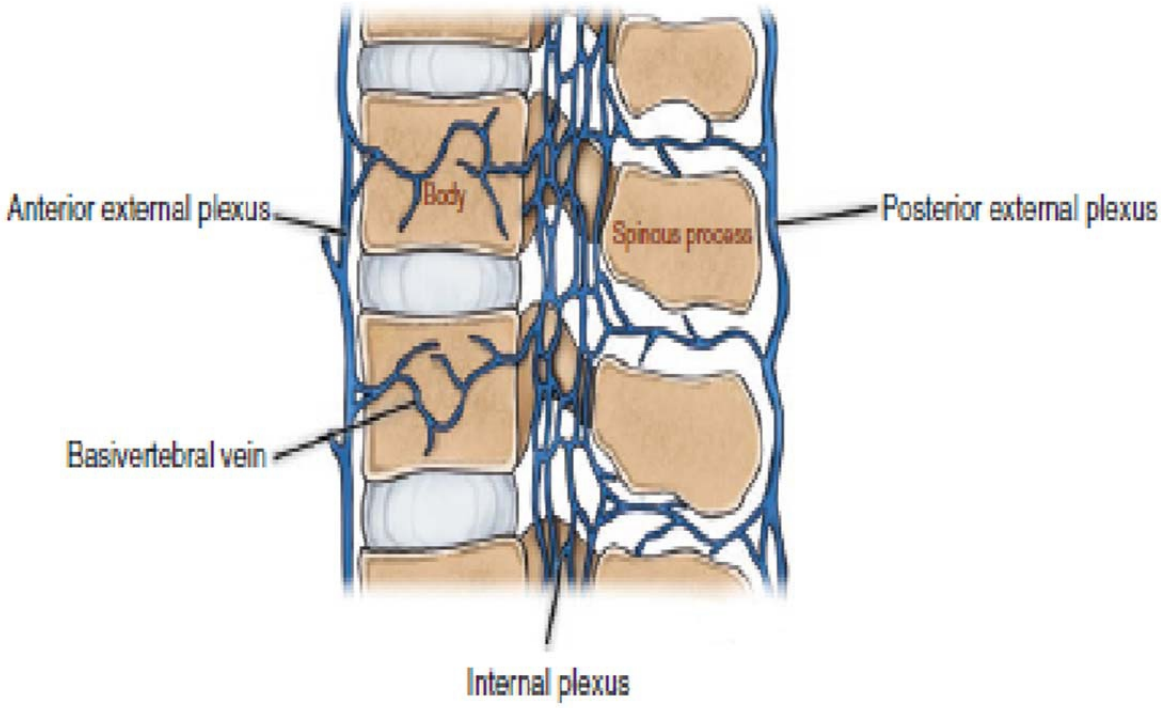
Lumbar Spine Anatomy - The lower back, known as the lumbar region, is mainly composed of five lumbar vertebrae and takes the brunt of the upper body's weight. Intervertebral discs maintain the intervals between the vertebrae and function as shock absorbers throughout the spinal column, supporting the bones when the body moves.

Venous Supply

External Venous Plexus

The external venous plexus is a plexus of veins that surrounds the exterior of the spinal column. Depending on where they are relative to the vertebral body, the veins are classified as anterior or posterior. Through intervertebral foramen (IVF) and transosseous routes, they connect with the segmental veins and internal venous plexus.

Venous plexus of lumbar spine Image-



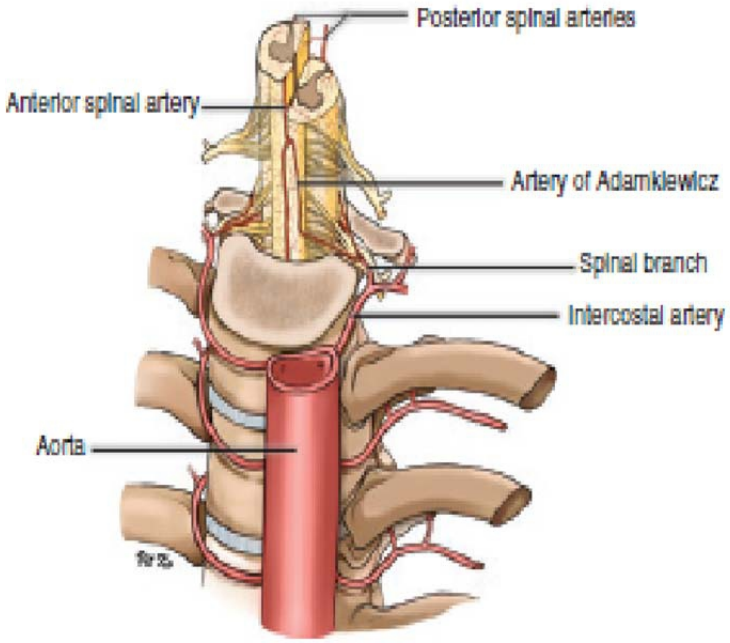
Internal Venous Plexus

The internal venous plexus is mainly composed of veins embedded in a layer of loose adipose tissue beneath the bony parts of the vertebral foramina. The Batson plexus is formed by a network of interconnecting longitudinal channels that run anteriorly and posteriorly to the canal. This is a valveless plexus, which makes it unique. The venous plexus around the foraminal region is the site where most of the surgical bleeding

occurs, necessitating extra caution during dissection. For surgery to be effective, bleeding must be avoided or controlled.

Arterial Supply

The lumbar segmental arteries provide external arterial flow to the lumbar spine. Through IVF (intervertebral foramen), the lumbar segmental arteries transmit the spinal branches to the vertebral canal. Each spinal branch separates into three branches as it enters the IVF , The laminae, ligamentum flavum, spinous processes, articular processes, posterior epidural tissue, and dura are all supplied by a single branch that runs posteriorly . The posterior part of the vertebral body is supplied by the anterior branch. The ventral and dorsal roots are supplied by a third branch (neural branch) that runs to the spinal nerve.



Arterial supply of lumbar spines

Lumbar Anatomy Based on Columns Concepts -

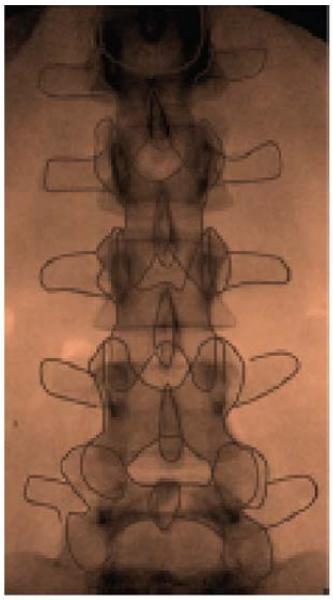
Based on biomechanical stability tests, Denis separated the vertebral column into three parallel vertical columns . The three columns are as follows:

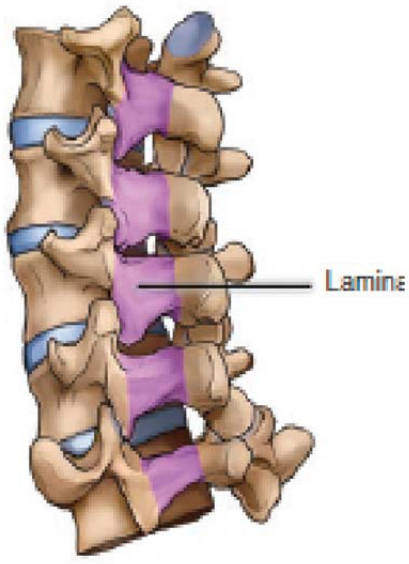
1 The anterior column, which includes the anterior longitudinal ligament, anterior two-thirds of the vertebral body and anterior two-thirds of the intervertebral disc (annulus fibrosus).

2 The middle column includes the posterior one-third of the vertebral body, posterior one-third of the intervertebral disc (annulus fibrosus), and posterior longitudinal ligament.

3 The posterior column includes the pedicles, facet joints, articular processes, ligamentum flavum, neural arch, and interconnecting ligaments.

Laminar anatomy of the lumbar spine with intraoperative fluoroscopic view –

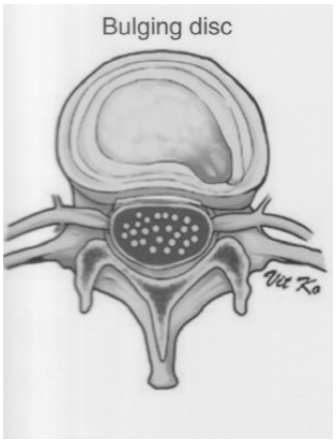


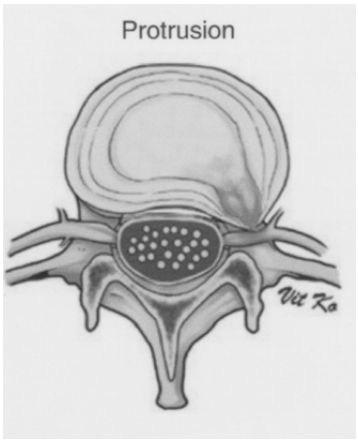


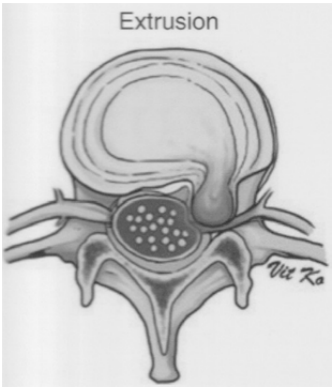
Lumbar Disc

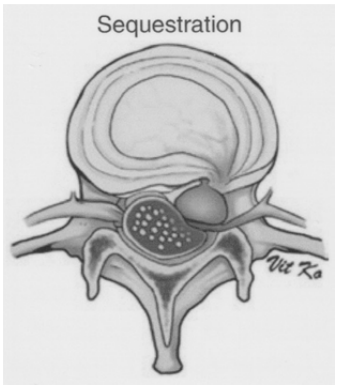
Type I collagen, water, and proteoglycans constitute the annulus tibrosus, which is known for its flexibility and tensile strength . The collagen to proteoglycan ratio is high, whereas the ratio of proteoglycans is low. Compressibility is a property of the nucleus pulposus that is composed of type II collagen, water, and proteoglycan. The proteoglycan/collagen ratio is low because of the high polysaccharide and water content, and proteoglycans interact with water and resist compression in hydrated gel.

Disc herniation is defined as a focal displacement of disc material (<25% of the disc circumference) beyond the limits of the intervertebral disc space . A contained herniation is defined if the displaced portion is covered by outer annulus fibers and/or the posterior longitudinal ligament. The herniated lumbar discs are divided into three groups. Bulging lumbar disc (not considered as herniation), Protrusion lumbar disc, Extrusion lumbar disc Sequestration lumbar disc









Classification	Description	Notes
Bulging lumbar disc	The presence of disc tissue extending beyond the edges of the ring apophyses, throughout the circumference of the disc	Not considered as herniation
Protrusion lumbar disc	Greatest dimension of extraannular disc material is less than that of the plane of contact with the annulus	
Extrusion lumbar disc	One measure of extra-annular disc material exceeds the diameter at the plane of contact with the annulus	
Sequestration lumbar disc	Displaced fragment that loses contact with its site of extrusion	A subset of extrusion

Lumbar Nerve Root Various Types and Anomalies-

The most frequent abnormality is conjoined nerve roots. Several types of nerve root abnormalities are present in anatomical investigations. However, they are less common in diagnostic imaging, indicating that they are clinicaly underrecognized, because the atypical and unrecognized roots may be damaged . These congenital malformation may account for some of the poor results after lumbar disc surgery. This becomes much more of a risk with some minimally invasive techniques that may not allow direct nerve visualization.

Conjoined roots have been anatomically categorized.

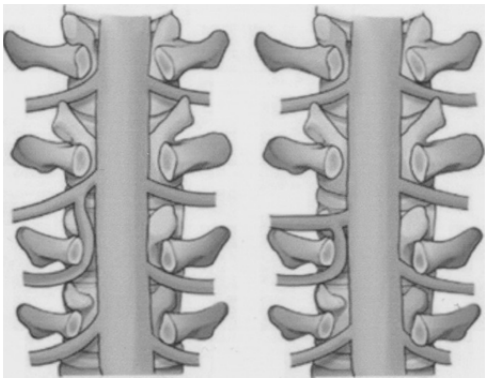
There are three classes, with the first two classes having subdivisions. When two roots exit the dura with one common sheath, it is known as type 1. The cephalad root exits the conjoined stalk at an acute angle to pass below the appropriate pedicle in type 1A abnormalities, and the caudal root travels through the canal to exit below the appropriate pedicle. A type IB anomaly occurs when the cephalad root exits at a 90° angle from the conjoined section.

Type 2 abnormalities occur when two roots exit through a single foramen. A part of one of the roots exits by the other foramen, which may be cephalad to the foramen inhabited by the two nerve roots in type 2A anomalies; while in type 2B anomalies, a section of one of the roots exits via the other foramen, which may be cephalad to the foramen occupied by :he two nerve roots.

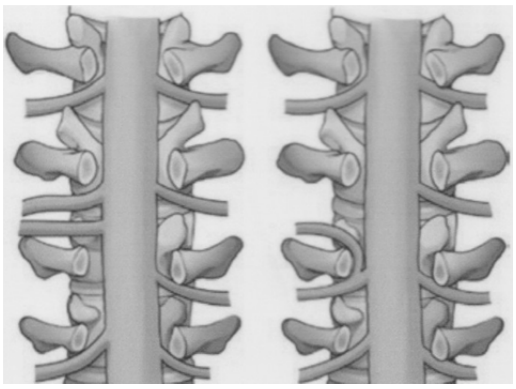
Type 3 abnormalities occur when an anastomosing branch connects two adjacent nerve roots.This branch crosses into the disc space and is susceptible to injury during discectomy. Conjoined roots are normally less mobile than normal roots; they might be separated accidentally and damaged by excessive tension. The L5 and SI levels are the most prevalent regions of the conjoined roots.

A furcal nerve root is the second type of abnormality that may be as prevalent as conjoined roots, in which nerve divides in two parts, branch which is less than 2 mm can be sacrificed.

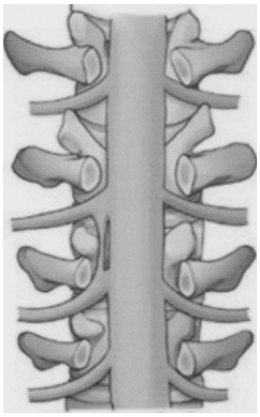
Type 1A and 1B conjoined nerve root



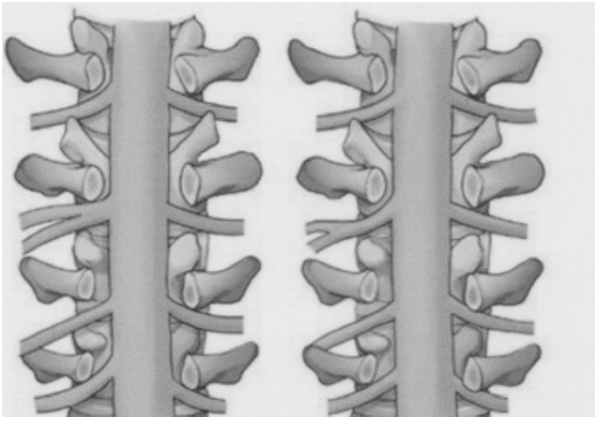
Type 2A and 2B conjoined nerve root



Type 3 conjoined nerve root



Furcal nerve roots



Pedicle Morphology -

Pedicle angulation of the lumbar spine for LI is 12°, L5 is 30*. and SI is 39°; pedicles angulate more medially as they move distally. The midpoint of the transverse process is used to determine the superior inferior dimension of the pedicle. The pedicle of L1 has the smallest diameter in the lumbar spine. The pedicles of men are typically wider and larger than those of women. The caudal index-level pedicle acts as the principal anatomical landmark in the transforaminal lumbar approach.

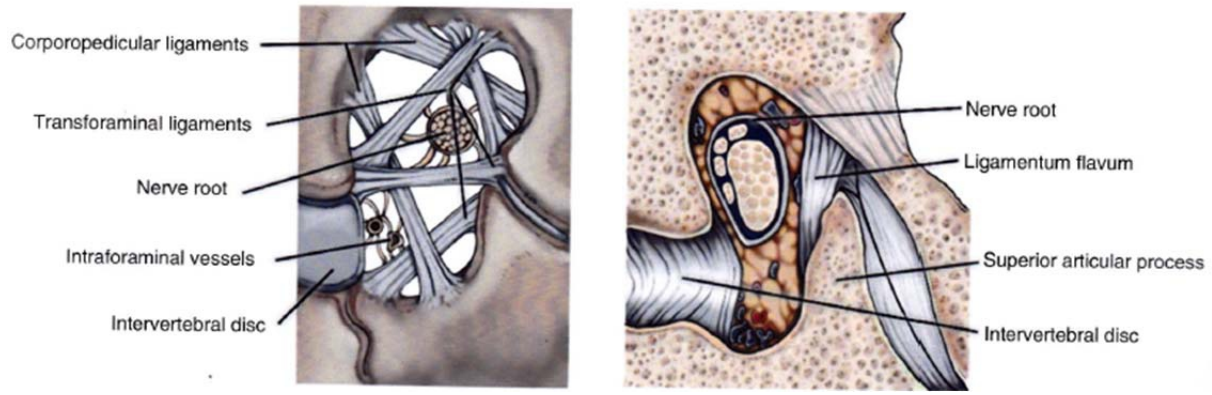
Neural Foramen -

For effective full endoscopic discectomy entire decompressed nerve root, whether traveling or exiting should be identified. The spinal nerve curves anterolaterally along the base of the subjacent pedicle and transverse process as it approaches the foraminal exit. The spinal nerve is divided into the primary anterior and posterior rami around the foramen exit zone. Position, alignment, and lumbar lordosis affects the dimension of lumbar neural foramen. The space of the neural foramen decreases when lumbar spine extension is applied, on the other hand, it increases when neutral or lumbar flexion is applied. Using a sponge bolsters corrects lumbar lordosis and increases the anteroposterior dimension of the foramen, **allowing the working cannula to pass more easily.**

The nerve roots are protected by the intraforaminal ligaments and adipose tissue. The nerve root is fixed in place by a network of ligaments that joins the periosteum. The yellow ligament extends into the foramen along the ventral portion of the inferior articular process and SAP.

The “empty zone” is located caudal to the yellow ligament attachment site. The posterior boundary of the foramen is formed by the ventral bony surface of the SAP at the inferodorsal aspect of the foramen. The empty zone functions as a portal for the lateral recess. The target area for the trans SAP and extraforaminal approaches is the ventrolateral surface of the SAP. The foraminal yellow ligament is a reliable landmark for identifying ventrally exiting nerve roots.

Intervertebral foramen structure –



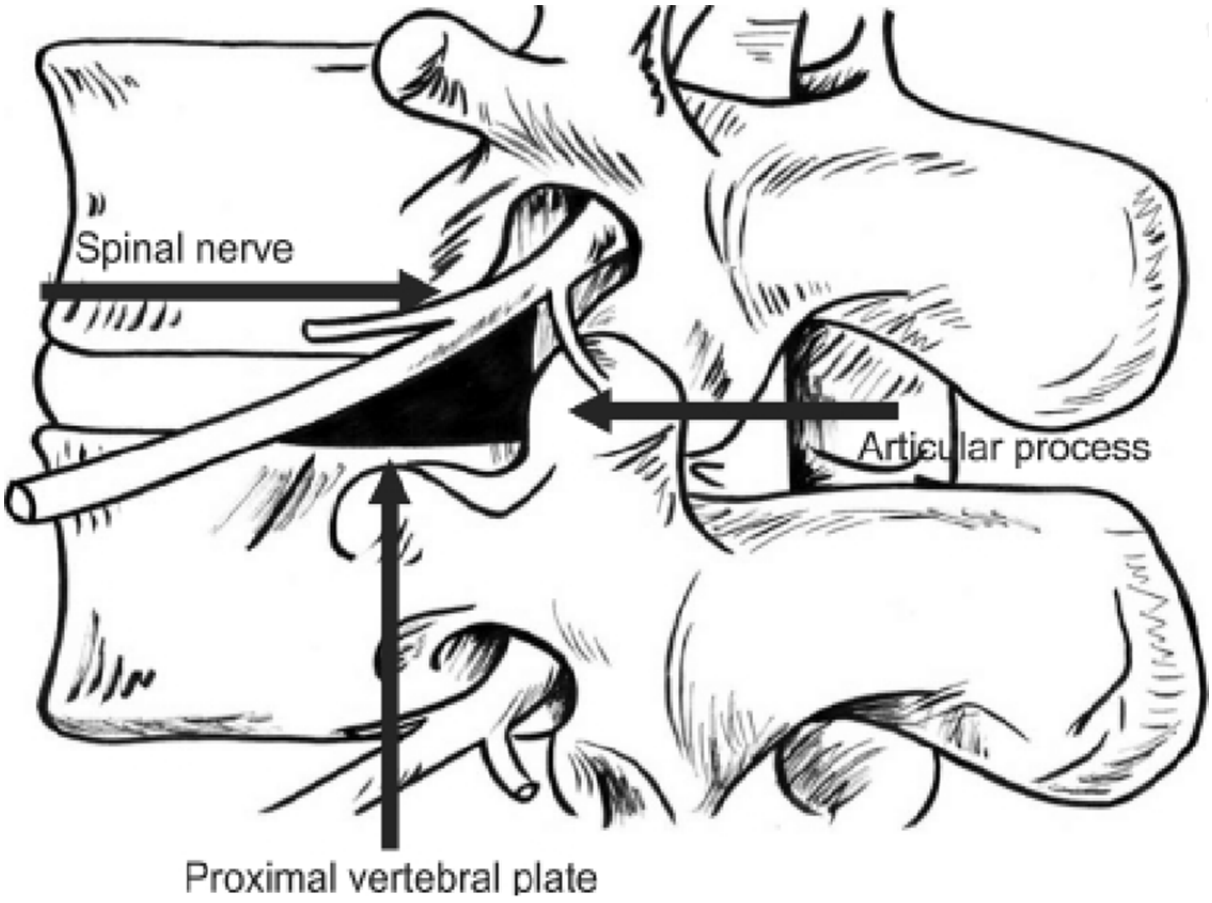
Surface Anatomy -

The level of the superior border of the iliac crest in relation to the associated disc space is essential when deciding on a surgical approach. Lumbar spinous processes are the most prominent and may be the only palpable landmarks in the lower back. Compared with the thoracic spinous processes, the posterior tip has a flatter surface. The tips of the transverse processes are approximately 5 cm from the midline and not perceptible. The L4 spinous process is usually parallel to the superior border of the iliac crest. However, in 20% of the population, the iliac crest is parallel to the L5 spinous process. Although fluoroscopy helps to identify the appropriate vertebral level for endoscopic operation. knowledge of the surface anatomy is required for a better topographic orientation during surgery.

Kambin's Triangle

The zone around the superior endplate of the inferior vertebral body, superior articulating facet, and exiting nerve root is called the Kambin’s triangle. Kambin's triangle is a triangular safe zone bounded inferiorly by the rim of the vertebral endplate, posteriorly by the lateral edge of the SAP of the next inferior vertebra, and hypotenuse by the medial border of the associated spinal nerve. Kambin and Hijikata

introduced endoscopic surgery as a less intrusive treatment for lumbar disc herniation in the 1970s, and it has since been generally acknowledged. Kambin defined the Kambin's triangle for this surgical approach, with the exiting root as the hypotenuse, inferior border of the lower vertebral body as the base, and articular process and superior articulating facet of the caudal vertebra as the height. Kambin's triangle becomes narrower at L5/S1 than at L4-5 based on the location of the exiting nerve root. A safe approach toward the upper part of the root for delivering cannulas and endoscopic equipment for nucleotomy or endoscopic discectomy can be established using this approach.



Kambin's Triangle's Base is caudal vertebral body, height is traversing nerve root, hypotenuse by exiting nerve root.

Chapter – 4

ADVANTAGE COMPLICATION & MANAGEMENT

Advantages of endoscopic spine surgery --

The main benefits of spinal endoscopy are decreased bony and soft tissue damage & muscle trauma so decreasing soft tissue stripping, and minimizing bony resect- ion prevents iatrogenic instability and provides patients with decreased pain and disability.

when compared with equivalent open surgeries. In addition, endoscopy allows the surgeon to avoid iatrogenic damage more adeptly to native tissue by enabling more direct visualization of anatomy and a more targeted approach to the patholo -gy. Sensibly minimizing iatrogenic damage to the musculoskeletal anatomy could be successfully translated in diminished blood 1oss, lower postoperative pain, and consequently faster postoperative mobilization.

Furthermore, endoscopy represent a tool for the spine surgeon to provide targeted access to spinal pathology and ultimately elevate the standard of treating patients.

The reduced soft tissue and muscular damage could even be monitored with decreased postoperative creatinine kinase levels.

Moreover, risk of iatrogenic instability and resultant adjacent segment disease theoretically minimized. Recent evidence supports the feasibility of spinal endoscopy without general anesthesia, making it very conducive to the outpatient surgical setting

Complications of endoscopic spine surgery –

Complications including durotomies, neural injury, cauda equina syndrome, wound infection, iatrogenic facet damage and instability, symptoms persistence, posto - perative discitis, and hematoma.

Most complications occur when surgery done on contraindicated pts.

Complications and their treatment –

Iatrogenic dural tear is a relatively common complication in lumbar spinal surgery, and in case of endoscopic procedures, incidence of dural tear increases.

The gold standard of treatment for iatrogenic dural tears during endoscopic procedures is an immediate switch to open surgery in order to allow a direct repair under microscopic visualization.

Nerve Root lnjury –

With the transforaminal endoscopic approach, a foraminal route must be used which is related to several increased risks such as segmental artery and dorsal root ganglion (DRG) injury. The segmental artery can incidentally be injured during cannula manipulation, leading to retroperitoneal hematoma. The DRG can be protected by a careful cannular retraction during the discectomy.

In most of the cases conservative treatment is sufficient.

Nonetheless, this process can injure the DRG and lead to postoperative dysesthesia.

Transient root palsy is deflned by new onset of aggravating hypesthesia without muscle weakness, all cases achieving complete alleviation with conservative therapy in 3 months.

Postoperative Hematoma -

The incidence of symptomatic postoperative spinal epidural hematoma is rare and can be managed conservatively.

Symptoms and signs associated with PSEH usually occur within 24 h after removal of the drain tube.

When it occurs in the cauda equina area, paralysis, radiating pain, and dysuria can be observed. As it is considered as one of the most common causes of neurologic damage after spinal surgery, postoperative imaging should be performed if susp -ected. If identified, it is necessary to carefully monitor changes in the patients' symptoms in order to assess if further operative measures are required.

If patient presents with new neurologic deficit should undergo subsequent surgical evacuation. Retroperitoneal hematoma, following the injury of terminal branches of the lumbar artery has also been described. this requires urgent evacuation and is a life threatening complication.

Recurrense-

Disc reherniation depend on the degree of initial herniation, the anatomical location

within the intervertebral space, and on the extent of the initial discectomy. Factors associated with recurrence after endoscopic spine approaches have been reported in several studies and include limited discectomy rather than aggressive discectomy, larger annular defects, obesity, larger disc height, and sagittal range of motion.

When needed, revision surgery is far more challenging than primary surgical treatment. Epidural or perineural scar tissue can be a troublesome issue that can hinder the otherwise easier dissection during a posterior approach, increasing the risk of complication (mostly dural tear or nerve injury).

Sequestrated herniations had a signiflcantly greater rate of reherniation than protruded or extruded discs.

Lnfections -

Deep and superficial surgical infections are a well established complication of spine surgery. The incidence of spinal infection seems to be increasing in recent years as a result of the higher life expectancy in elderly patients with chronic debilitating diseases and the rise in the prevalence of immunosuppressed patients. Common predisposing factors for pyogenic spinal infections, excluding postoperative infections, were in order of frequency of smoking, intravenous drug abuse, diabetes, liver disease, end-stage renal disease, malignancy, and human immunodeficiency virus.

Most cases of spinal infections can be managed by antibiotic therapy without surgical intervention before the development of neurologic deficits, cauda equina syndrome, spinal instability or vertebral collapse, progressive spinal deformity, abscesses not responding to altibiotics, and failed radiologically guided biopsy necessitate open surgical procedures without instrumentation.

Chapter -5

INSTRUMENTATION IN ENDOSCOPIC SPINE SURGERY

Following instrument are needed in endoscopic spine surgery -

Camera system & endoscope -

High definition 4 K camera system was developed . It allows recording and transferring images up to 4 K resolution. It is important to ensure surgical safety, optimize the surgical fleld visualization, and avoid iatrogenic damage to neural tissue due to poor vision. LED light sources are generally used to provide illumination. The light is transmitted to the distal end of endoscope through flexible fiberglass light cable.

Image of 4K camera system & moniter

Fluid Management –

Fluid management in full endoscopic spine surgery is important. It helps for clear visualization, and also somehow can help to separate the neural tissue away from the ligamental flavum when doing dissection. But dilatation of the epidural space is NOT the purpose as that in arthroscopic procedures. It is because we need to avoid developing critical pressure in the spinal canal and causing compression of neural structures, which may cause postoperative symptoms. Therefore, open system for fluid management is used in endoscopic spine surgery. A continuous inflow and outflow system is used to avoid building up of pressure.

Coagulation and Ablation of Soft Tissue –

Coagulation is crucial for safe endoscopic spine surgery. Blood will obscure the surgical view and even postoperative epidural haematoma could be developed if bleeding is not well controlled.There are few methods can help to control bleeding. First, adding adrenaline to the normal saline irrigation fluid can help to control diffuse oozing and bleeding. Furthermore, radiofrequency ablation is useful to control bleeding. Increase in flow rate of fluid can also help to maintain a clear visual field by washing away the debris. On the other hand, soft tissue ablation is commonly required in different indications in endoscopic spine surgery, which is another important function of Radiofrequency system. Radiofrequency systems in the bipolar application form together with actively articulatable electrodes are developed to serve the above purposes. The radio-frequency utilizes high frequency, low-temperature radiowaves to

perform traditional scalpel, scissor, electrosurgical procedures. The cell specifIc tissue effect affords unparalleled surgical precision while sparing healthy tissue. The low temperature emission results in nonadherent bipolar perfomance, which minimizes tissue trauma and eliminates frequent cleaning and instrument irrigation. The blunt, flexible and actively articulable electrodes enable access to the full field of view generated by the angled endoscope.

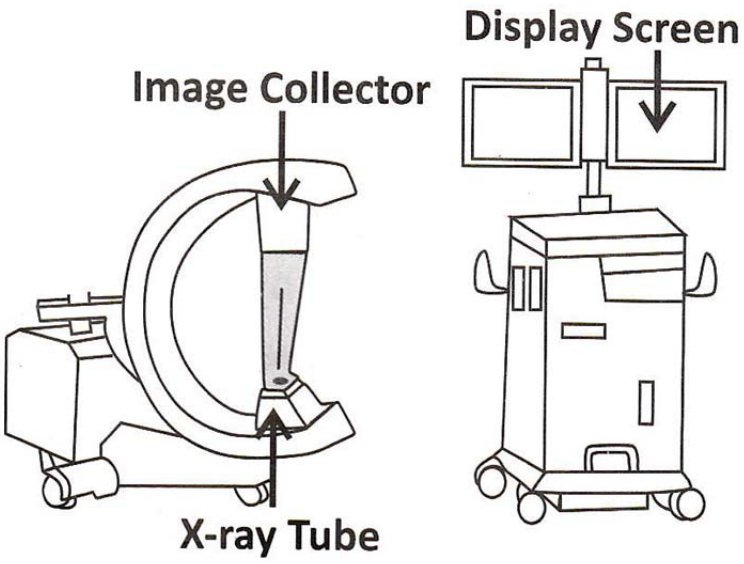
C Arm is core of any endoscopic spine surgery –

The C-Arm is a composed of three parts:

Part one is the production of X-rays, i.e. the x-ray generator tube.

Part two - The image collector which is an imaging plate on which photons fluorescence at a lower energy, this differential penetration of X-rays through an object and subsequent image formation in realtime is transmitted to screen.

Part three - The display screen or CRT tube on which the images are finally displayed.



Nowadays flat panel detector c arm available with better picture quality.

Following instruments are needed in transforaminal surgery -

THE NEEDLE –

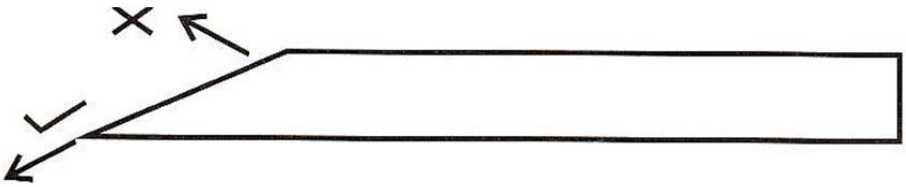
Proper use of the needle is the cornerstone of any successful Endoscopic Spine Surgery.

Dimension: 18Gx20cms, 18Gx25cms.

The endoscopic spine surgery needle is always with a leur lock and has L cm

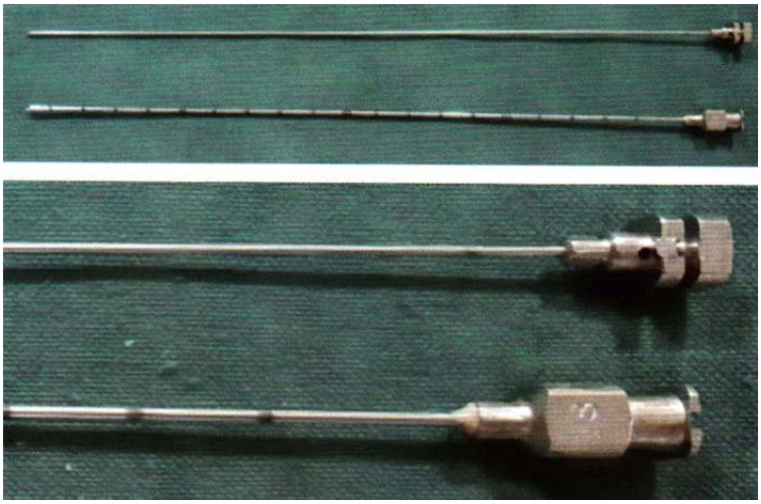
graduation marking. The lock and number in the leur always faces the Bevel edge. We may use a stopper for safety. As the bevel edge offers greater resistance when penetrating the tissues, the needle will deviate away from the surface of the bevel edge. This is of advantage in aiming.

The needle always goes towards the tip.



Needle goes downwards, not upwards

The spinal needle is 25 cm long and has graduated markings of 1- cm along it's length.

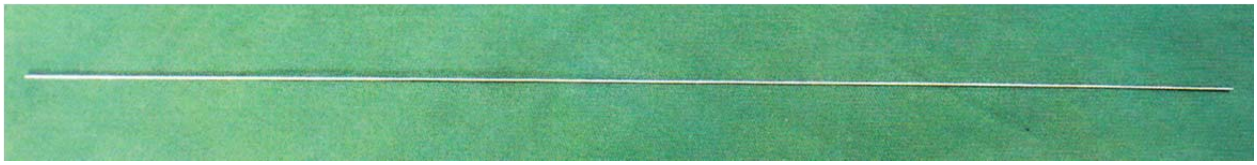


Guide wire -

The guide wire is a 0.9 mm x 41 cm long malleable steel wire which passes through the endoscopic spine surgery needle.

Function -

The guide wire is the pillar on which all subsequent instruments will be passed. After passing the guide wire through the needle, gradually remove the needle by gentle twisting movements (as the annulus, the inter-transverse ligament, and thoracolumbar fascia will have tightened around the needle or firmly grasped the needle), keeping your thumb on the guide wire. Rotary movements of the needle will gradually free the needle and allow you to gently pull it out without pulling the guide wire.

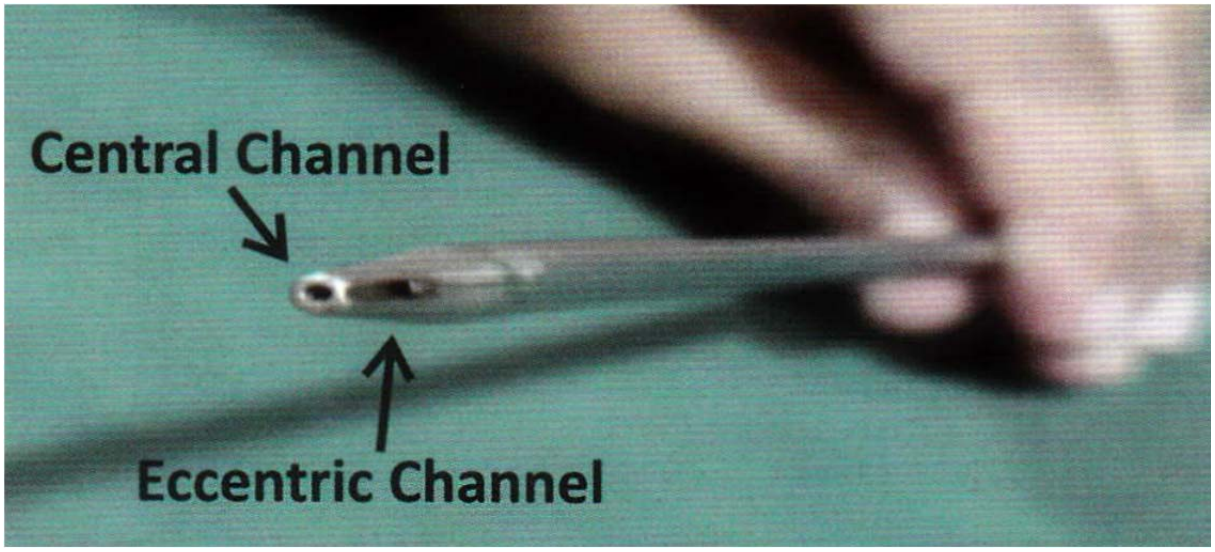


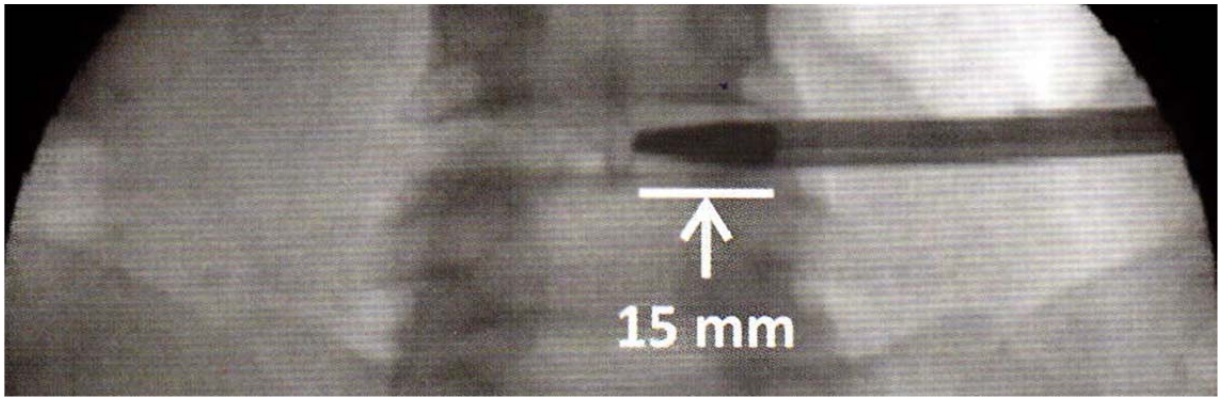
ln case of Trans-iliac and trans-forminal endoscopic spine surgery 2 mm x 41 cms guide wire in length is used. This is much more rigid than the usual 0.9 mm guide wire. lt can be mounted on a drill and directly used to drill through the iliac bone and land at L5-S1 foramen. (Tip should be sharp).

DILATOR – In the endoscopic spine surgery dilator is used to dilate a path in the most atraumatic manne rto the foramen and the spinal disc. The length is 22 cms. The

outer diameter is 5.8 mm in thickness and has 2 working channels in it. Each channel hole is of 1.4 mm. One channel is Central and the second channel is Eccentric.

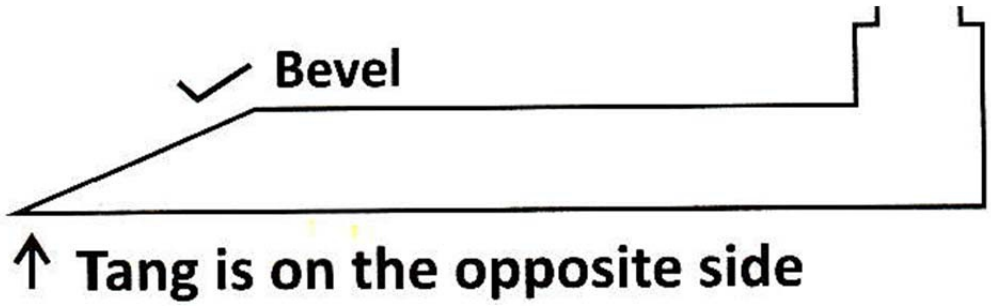
The dilator is crafted in such a way that it has two metals of varying densities. The proximal bit of l-5 mm i.e. taper is of higher density than the rest of the shaft. This allows visualizing the exact positioning of the tip in the spinal foramen under C-arm.





SLEEVE –

In endoscopic spine surgery sleeve is 17 cms in length, with centimeter graduated markings. lts outer diameter is 7 mm, inner diameter is 6.8 mm. The sleeve is mounted on a dilatorALWAYS. The tip is called Tang.



BURRS –

Burrs in endoscopic spine surgery is a most useful tool for working on SAP during visualized access to the foramen either for foraminotomy or foraminoplasty and oblique pediculectomy.

It is used in patients with:

Lateral canal stenosis due to enlarged facets due to hypertrophic tissue, or high riding superior articular process, osteophytes arising from the inferior endplate of the cranial vertebrae, and in patients of disc disease i.e. down migrated disc herniations, large central disc needing medialisation of window. Also in patients with stable degenerative lysthesis having foraminal stenosis.

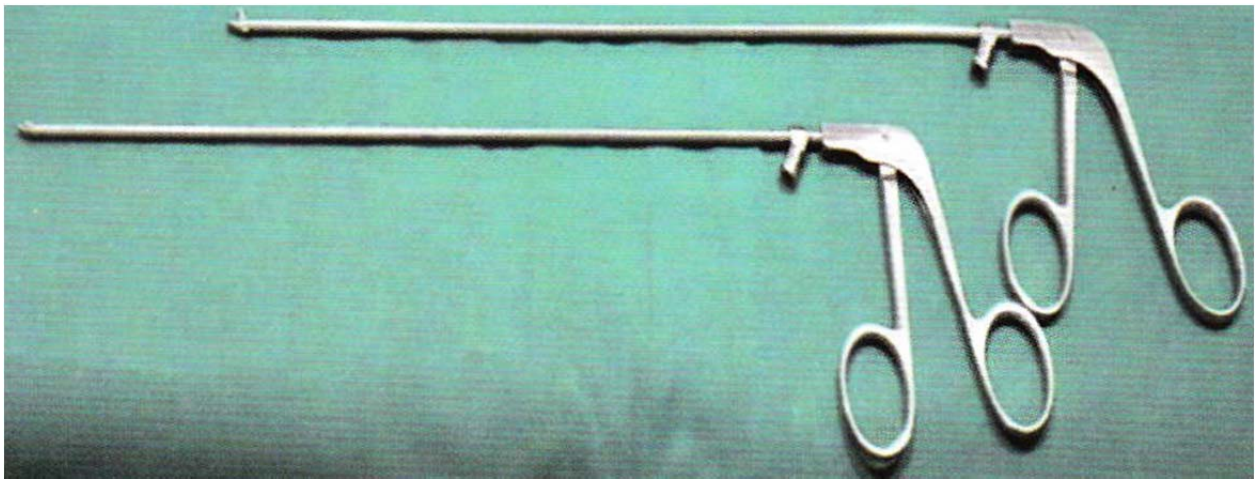
Burrs commonly used are - normal or diamond tip. Sizes in visualized burring are usually 2.5 to 3 mm.

ANNULOTOMES –

Annulotome is an instrument used to cut rigid annulus fibres, to allow access to trapped annular fragments and medialisation of window. A standard annulotome has bite of 8 mm and length of 300 mm. Annular fibers cannot be taken apart by use of

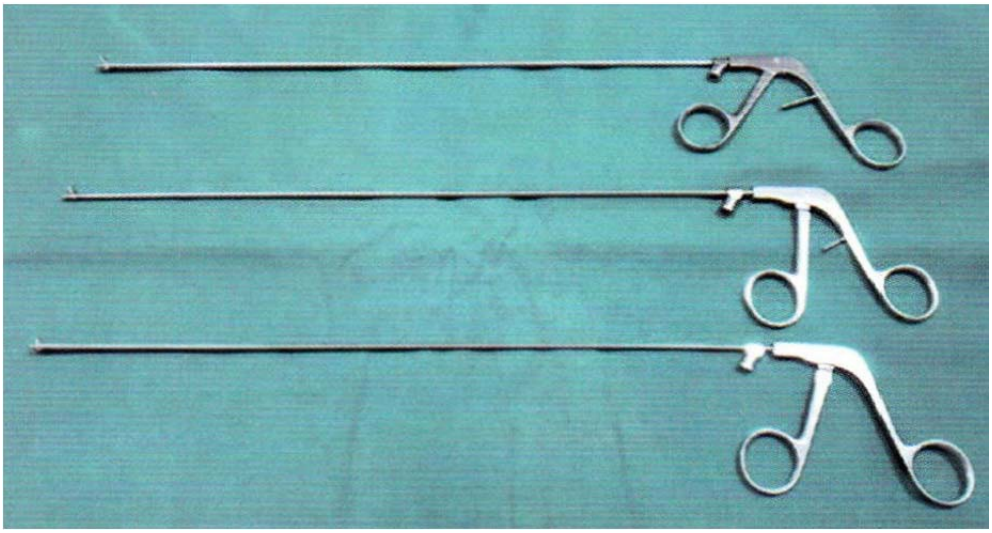
graspers and the need of annulectomy to release a herniation trapped fragment is necessary or in stenosis, where the annulus is hard, collagenised.

Annulectomy is mandated 'to release the entrapment of a large fragment and then grasping it out.



GRASPERS –

The grasper is the single most important tool for doi ng targeted fragmentectomy. It is the tool by which you grasp and pull fragments and deliver it through your scope. A set of good graspers is vital to reach every corner and pull out the offending fragments. The length of the graspers may vary from 30 - 36 cms. Standard endoscopic spine surgery scope has a working channel of 3.525 mm diameter. Standard graspers are available in 2.8 mm and 3.5 mm in diameter.



HOOK-

The most important general utility instrument which plays a great role in endoscopic spine surgery, the hook is used for:

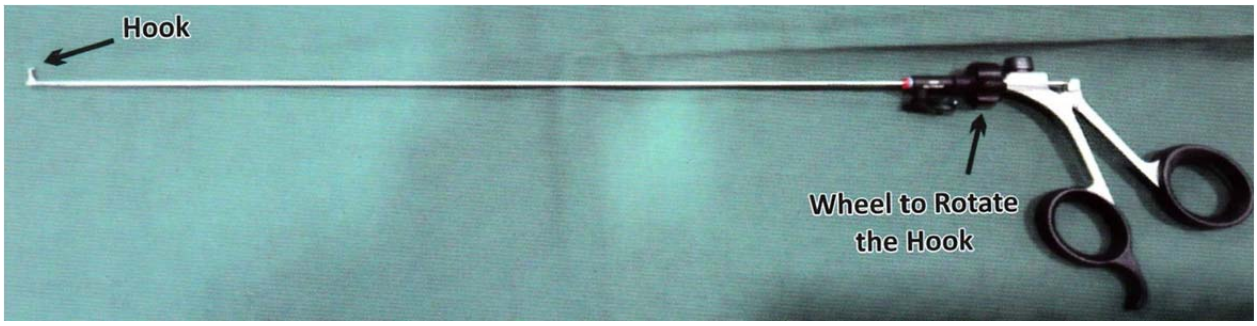
1,. Hooking of a fragment and pulling it towards you.

2. Probing the annulus fibrosus for entrapped fragment

3. Probing the epidural space through the rent in the annulus, for retrieving migrated fragments.

4. Routinely sweeping the epidural floor above the annulus after partially coming out for any loose fragments and confirming free root.

5. During facetectomy, use the hook at the distal end of the facetectomy to sepe rate the flavum or adhesions from the bone, prior to lateral recess decompression.



Endoscope –

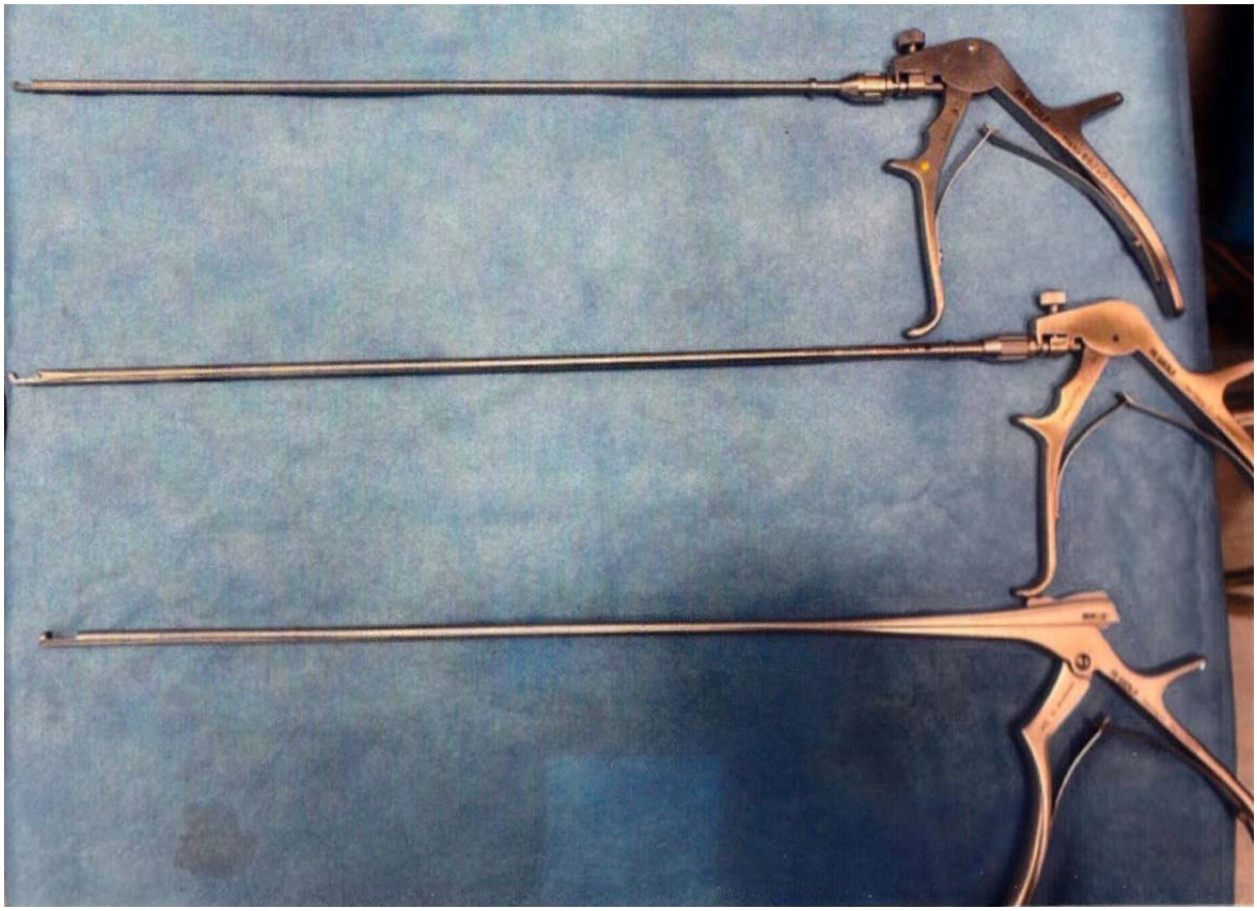
176 mm length 30 degree Scope with 7.3 mm outer dia & 3.7 mm working channel for transforaminal endoscopy.

Instruments for Interlaminar surgery –

Endoscope –

10 mm 25 degree 125 mm length scope for interlaminar surgery with 7 mm working channel.

Kerrison rounger –



Chapter -6

HOW TO DIAGNOSE PIVD IN MRI SPINE

HOW TO DIAGNOSE PIVD IN MRI

DR. VEDPAL YADAV

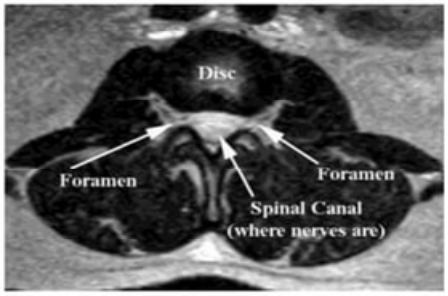
(CONSULTANT ORTHOPAEDICS)

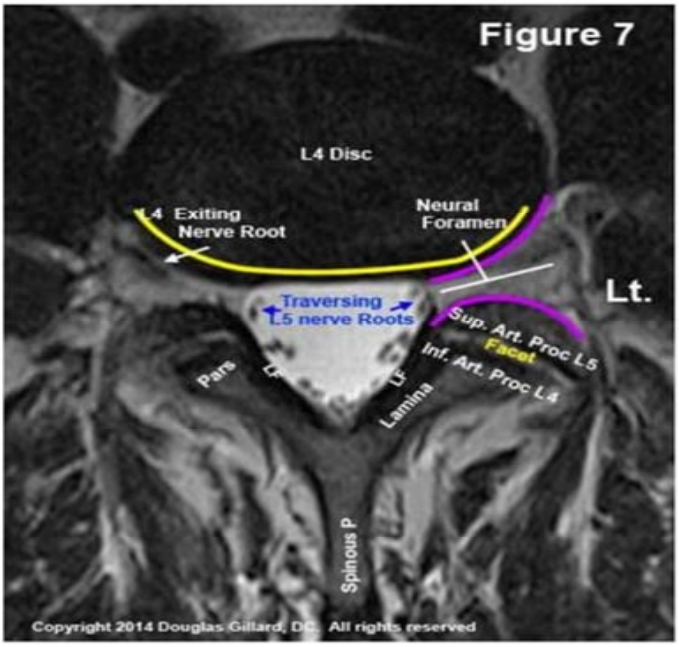
PROLAPSED INTERVERTEBRAL DISC

- Mostly seen in lumbar region followed by cervical region.
- Affects young adults 30-40 years who still have relatively maintained disc height.
- Male:female ratio 3:1
- 95% involves L4-5 and L5-S1(most common)
- Herniates through the postero-lateral corner of annulus fibrosus(thin region)
- Most commont causes:
  - Sudden violent trauma (sports injuries)
  - Less severe trauma in degenerated annulus(lifting, bending, coughing, sneezing etc)

Investigations- MRI

- Most accurate and sensitive modality for the diagnosis of subtle spinal pathology.
- It allows direct visualization of herniated disc material and its relationship to neural tissue including intrathecal contents.
- Advantages over myelography
  - No radiation
  - Non invasive
  - No intrathecal contrast
  - More accurate in far lateral disc
  - Disc disease of LS junction
  - Early disc disease

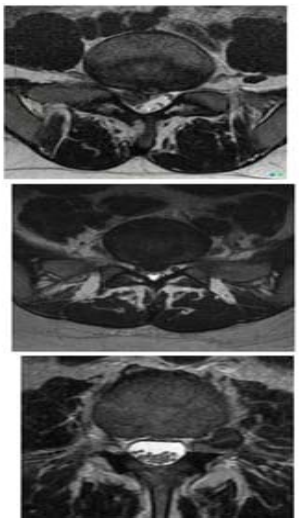




Classification based on the location of the disc herniation

- **Posterolateral/paracentral prolapse:**
  - Commonest
  - PLL weakest in this area
  - Herniated disc impinges on the traversing nerve roots(e.g the L5 nerve root in L4-5 disc prolapse)
- **Central prolapse:**
  - may present with back pain only or Cauda-equina(severe cases)
- **Foraminal/extra foraminal/far lateral herniation:**
  - Less common
  - The herniated disc impinges on the exiting nerve roots

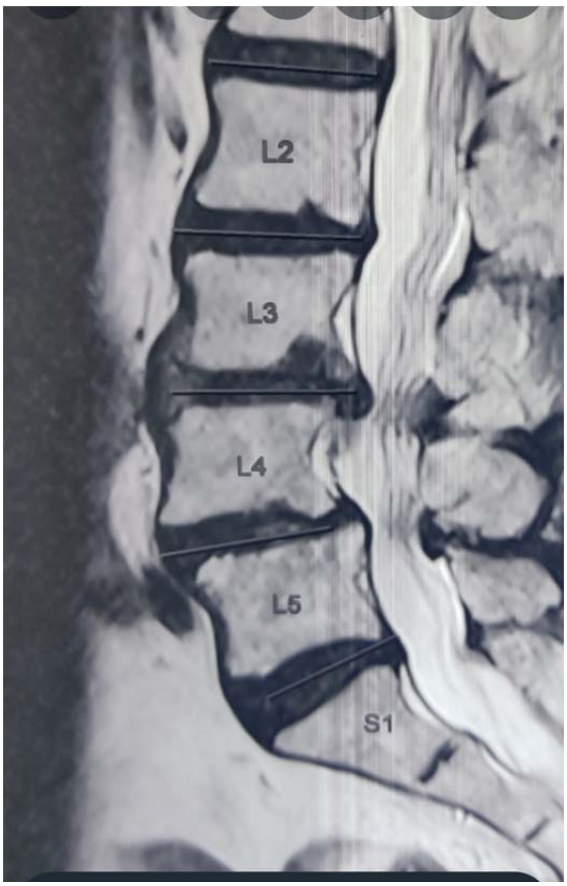
  (e.g. L4 nerve root in L4-5 level)



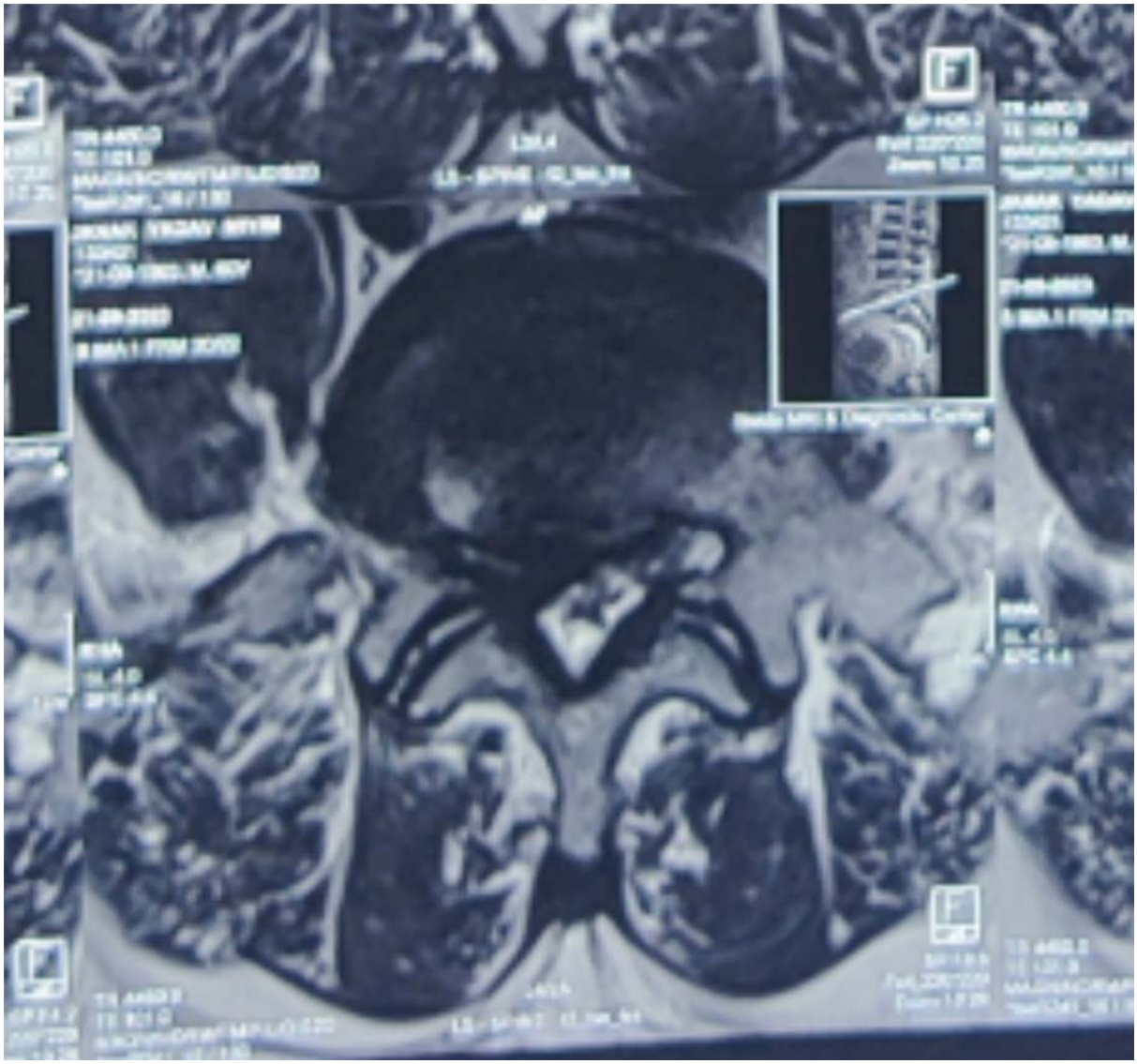
MRI is an essential investigation for diagnosis of neural compression in Spine and identification of exact Level of the disc herniation .

T2 Weighted images carefully looked in Sagittal & axial section for cephalic or caudal migration of the disc fragments.

Sagittal image -



Axial image –



Chapter - 7

ENDOSCOPIC SPINE PROCEDURES

Endoscopic spine procedures can be divided broadly in 2 groups.

1- *Transforaminal*
2- *Interlaminar*

Transforaminal procedures

Indications – Any herniation of lumber disc which is not migrated can be successfully treated by inside out technique and migrated disc can be treated by outside – in technique and foraminal stenosis can be treated by foraminoplasty.

PRE SURG ERY PREPARATIONS –

Any surgery planning has to proper be preceded by patient counseling. This is the foremost in the list of planning as a well prepared patient to be operated under awake and aware anaesthesia requires high level of cooperation.

Counselling carried out by the doctor should explainto the patient:

1- Advantages ofthe procedure
2- pitfalls of the procedure
3- Failure related to the procedure
4- Likelihood of dysaesthesia ,and core area pain for a transient period of time especially when foraminoplasty and root handling is done.

BASIC SET OF INVESTIGATIONS –

1 - MRI

2. X-Ray

3 – EMG- NCVfor both upper/lower limbs, as the case may be

4- Ultrasonography with pre and post void residual urine

5. Ches tX-Ray (PA)

6. ECG

7 . 2D Echo, if needed

8. Lab investigation -

A. Blood Sugar- Random (lf patient is diabetic, BSL - Fasting and PP)

B. HbAIC (lf patient is diabetic)

C. Hemogram (Complete Blood Count)

D. S. Electrolytes

E. S. Creatinine

F. S. Uric acid

G. C-Reactive Proteins

H. ESR

I. BT&CT

J. Prothrombin Time (PT INR)

K. U rea

L. Creatinine

M. HIV/ HBsAg/ HCV

N. Urine Routine --

O. Thyroid Function Test, if needed

9. Physician Fitness and Cardiologist fitness, if needed.

OPERATING ROOM –

The operating team essentialty consists of:

. Operating surgeon

. Anaesthetist

. Senior operating room nurse

. Two junior assisting nurses

. image intensifier technician

. Technician for handling accessory trolley

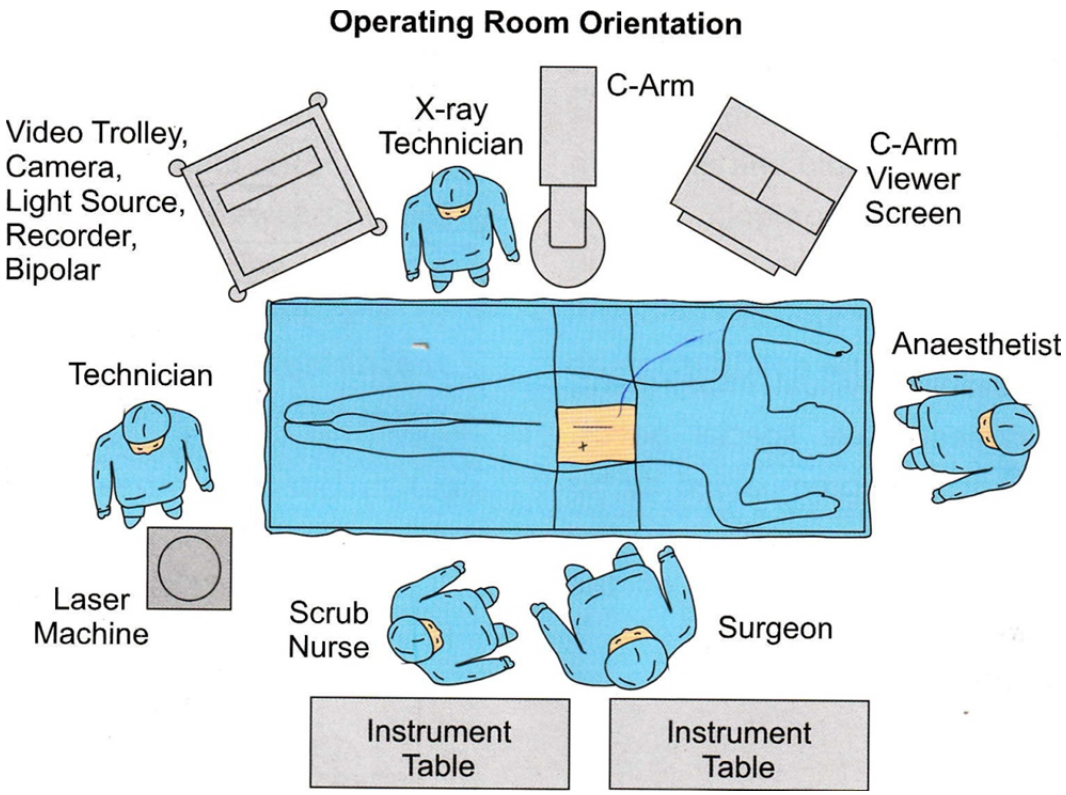
. lmaging machinery .

. Radio frequency machines

.Light source

. Laser machine

. lrrigation fluids, etc & General help



O P E RATI O N TABLE/BO LSTE RS/I RRI GATI O N –

OPERATION TABLE -

This essentially means a very high use of the image intensifier. To compliment this, it is

essentialto have an operating table which is image intensifier compliant and is radiolucent. Secondly, the operating table should ideally have a caudal end break which allows for the dropping of the pelvis and correcting the lordosis when operating at L4-L 5 and L5-S1 levels, if needed. Lastly, for taking lateral X-ray, the image intensifier has to swing below the operating table therefore, the operating table has to have a height adjusting mechanism, which if electrical is more easy to operate.

Bolsters – Endoscopic spine surgery procedure, especially when being done at multiple levels in the same sitting for foraminoplasty takes 3 to 4 hours. All this time the patient has to lie down on his / her abdomen, which can be a very uncomfortable position to be in especially in obese patients. Custom designed bolsters become very comfortable which allows for correction of the lordosis, accommodates the protuberance of the abdomen and at the same time gives adequate support to the back, so as to allow correction of lordosis by allowing the pelvis to fall during surgery.

IRRIGATION –

lrrigating fluid in endoscopic spine surgery is normal saline, available in convenient 3 litre

packs. Fluid control during surgery is of paramount importance.

l- cc of Epinephrine can be used with every litre of saline in dilution for control over bleeding, Addition of any antibiotic has not really been proven to be of any advantage. Use of a fluid pump with pressure setting not exceeding 200 mms of fluid pressure may be used, with enhanced pressure unto 30 cms in bursts controlled by foot pressure if needed. This helps to stop oozing from epidural veins as normal epidural pressure does not exceed l-5 mm of hg. Please be sensitive to rise of epidural pressure and neck pain, if patient complains of the same, drop pressure. Gravity assisted flow is also more than enough if height of lV stand is raised in most cases and a pump is not needed. A urology irrigating tube has dual chambers which when squeezed by assistant or operating room nurse, can give transient rise in flow pressure, there by not needing a pressure cuff around the irrigating fluid bottle. Cold saline may be useful to stop bleeding.

Water bottle with TUR set –

C-Arm lmaging –

During C arm use ln the AP shoot, the closer the image collector is to the patient, the lesser will be the scattering of X-rays. lt will also improve the image quality and reduce the radiation doses due to scatter throughout the operation theatre and reduce magnification. ln underthe table movement of the C-Arm for lateral shoot, the operator of the machine is usually facing the X-ray generator. This puts him directly in the path of the oncoming radiation beam hence, please advise the operator to use extension switch and move out of the range of the beam.

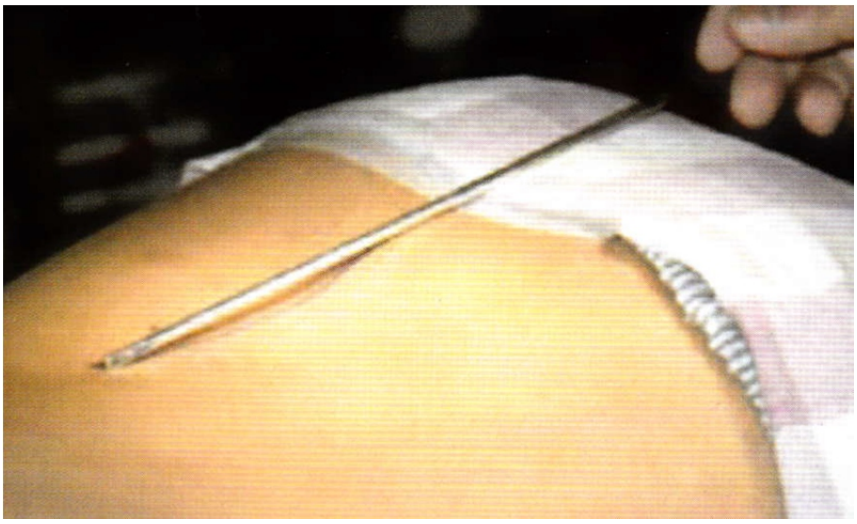
Only in cases of L5-S1 Disc, a 15 degree tilt of the image collector towards the cranium is required and is called Ferguson's view. ln this view the L5-S1 disc will open up as you are aligning with the lordosis of the patient. At L4-L5 a 5" tilt, at L5-S1 l5' tilt and Ll-L2, L2-13 reverse tilt towards leg may be needed.

SKIN MARKING –

Endoscopy is a precise art, as the underlying philosophy has evolved form debulking to precisely ta rgeted f ragme ntectomy. Where you land determines the exact ability to remove the fragment and treat the pathoanatomy. Howeve; basic targeting has been determined by the boundaries of the Kambin's triangle. This is the holy grail, that cannot deviate as safety is paramount and every single time targeting has to land you in the Kambin's triangle between the two end plates and two nerves.

Markthe midline -

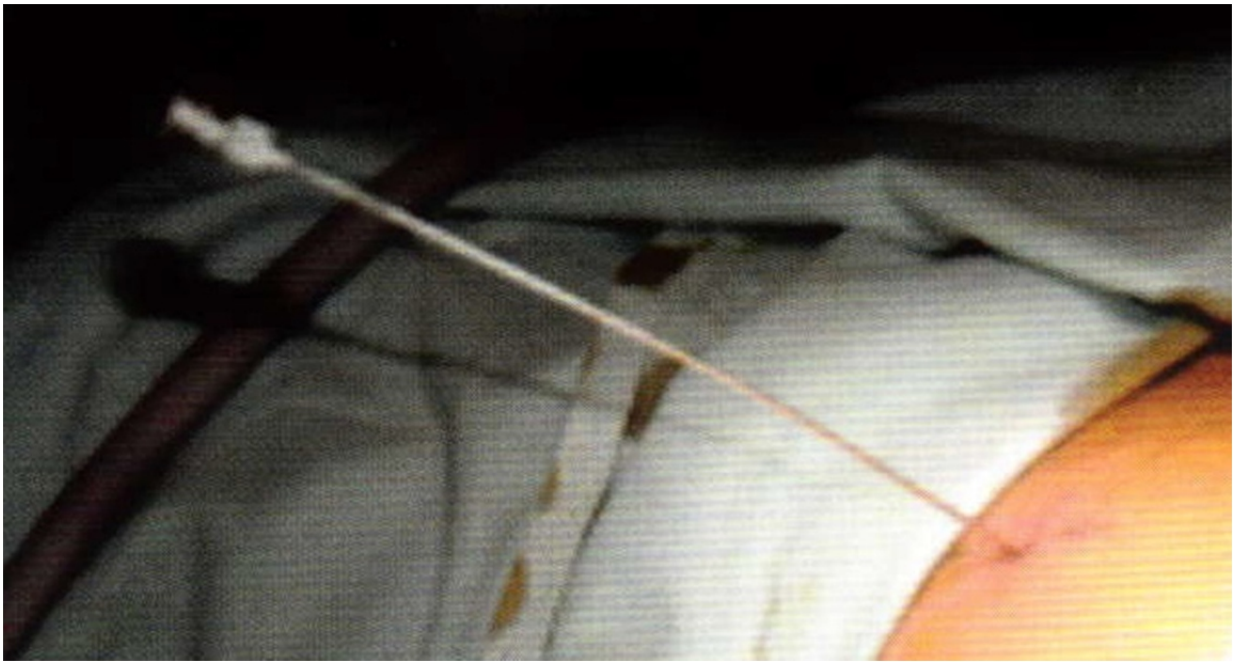
Use a metallic marker to mark the midline under C-arm guidance. The skin is marked with a permanent marker ink pen. Marking the midline is essential for proper orientation.

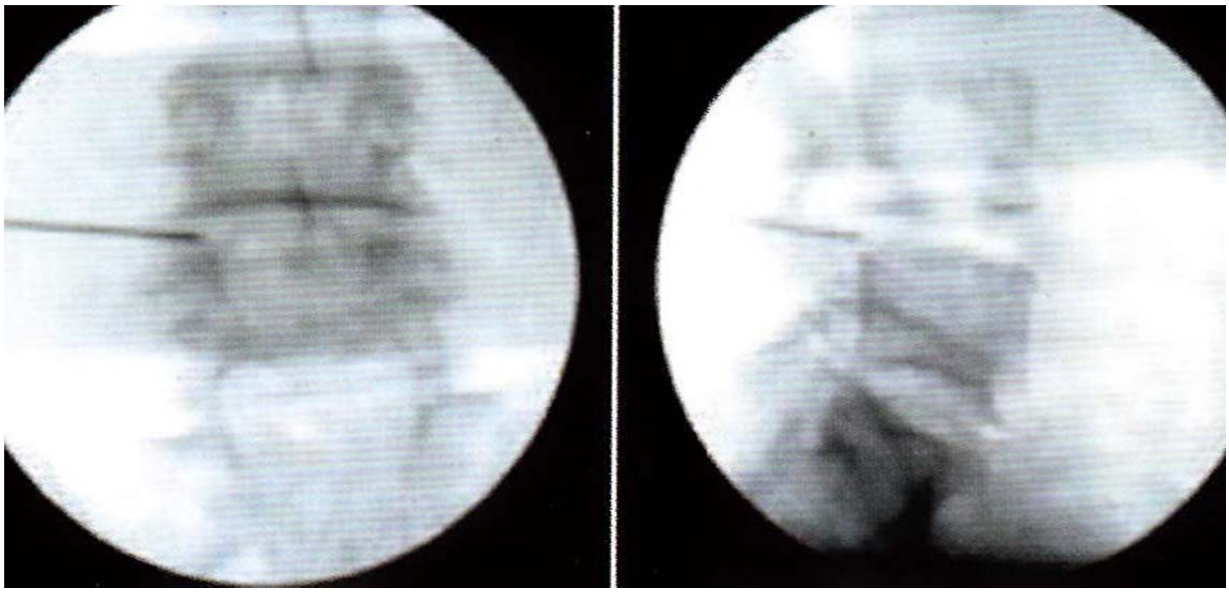


Marking of the depth of the disc –

Marking of the depth of the disc from its anterior border to the level of the back plain helps to determine the entry point.

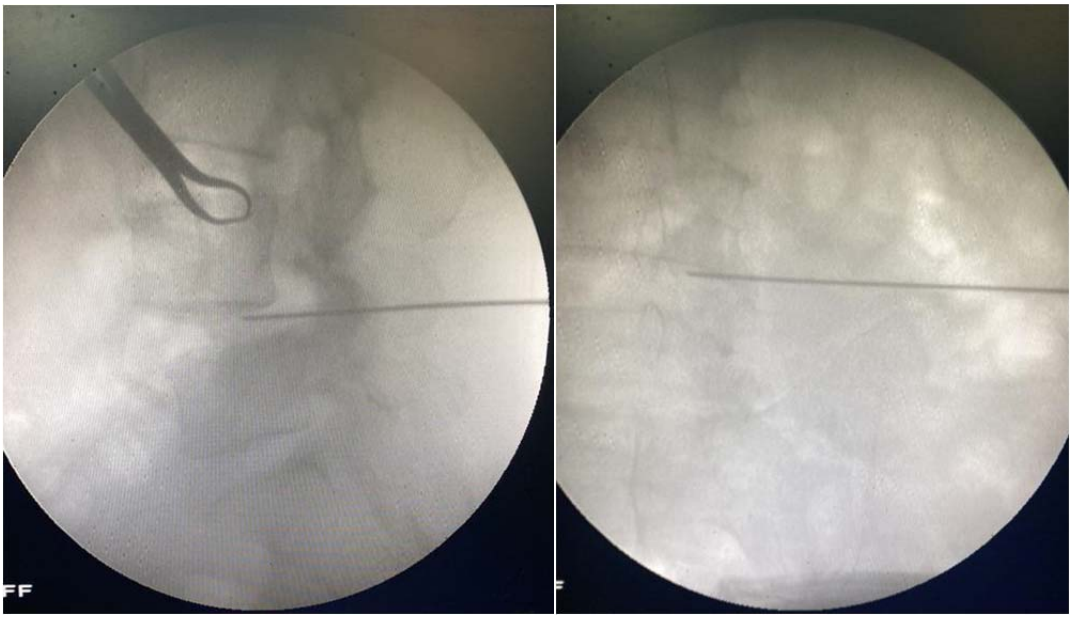
Insertion of Needle - Needle insertion is the key to all surgery. it must be exact and precise. IT IS DONE WITH 18 GAUGE NEEDLE.





When needle crosses mid pedicular line it must be on posterior end of intervertebral disc & when it crosses medial pedicular line it must be on disc space.

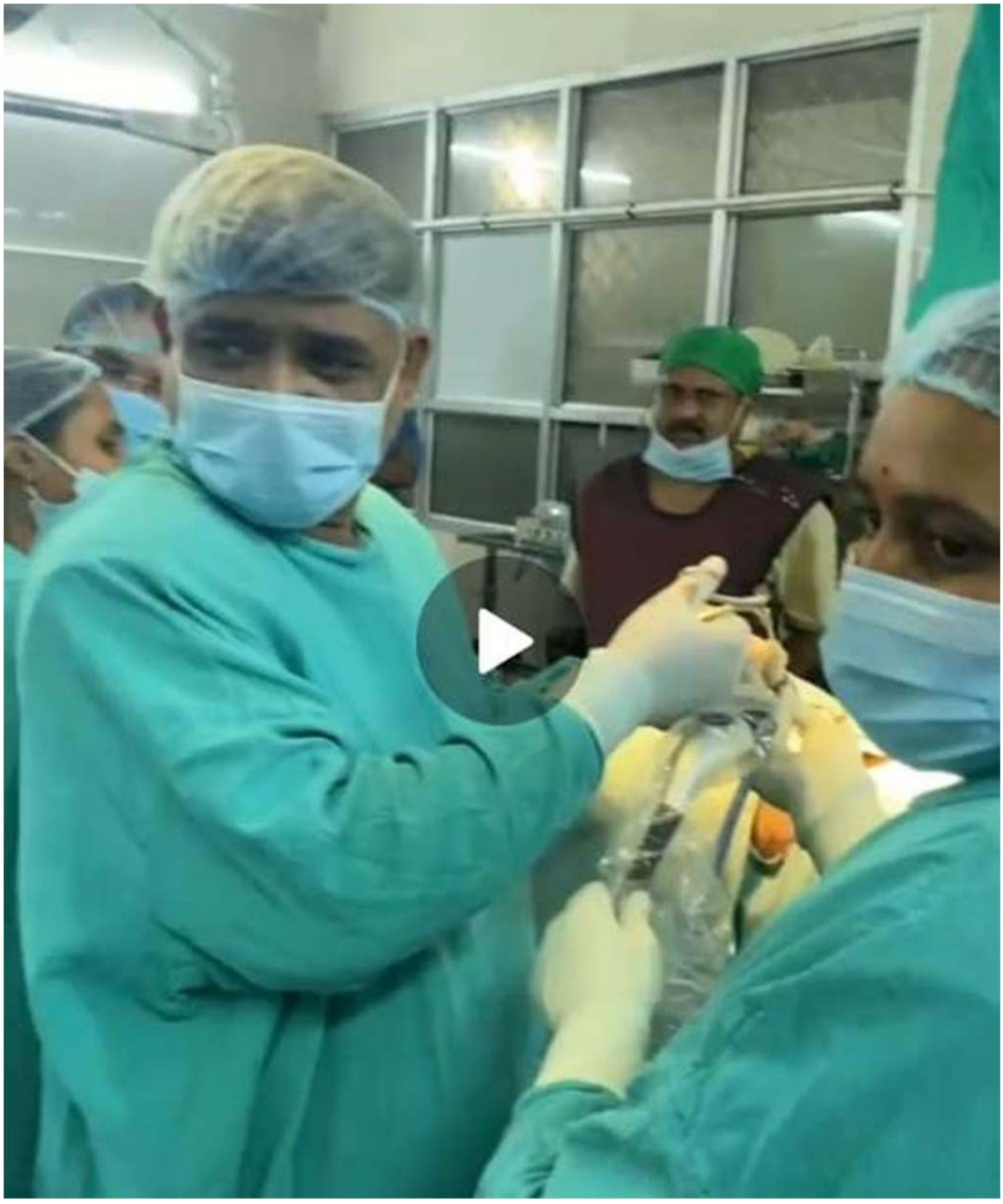
When needle approaching midline in AP view then it should be in posterior third of vertebrae.



After this 22 gauge guide wire should be introduced in needle then needle removed and dilator placed over guide wire and finely sleeve over dilator placed.

Then endoscope introduced.

A still with endoscope from video doing transforaminal endoscopic spine surgery



Disc material should be inspected for any granulation tissue and weighted –

INTERLAMINAR PROCEDURE –

Indications – Any herniation of lumber disc which is migrated CRANIALY OR CAUDALY & SEQUESTRATED can be successfully treated BY INTERLAMINAR APPROACH and foraminal stenosis can be treated by CONTRALATERAL APPROACH.

DISC MIGRATED DORSAL TO SPINAL CHORD CAN BE TREATAD ONLY BY interlaminar approach.

Pre surgery preparation, investigation, operating room preparation, irrigation are same as in transforaminal.

C arm imaging –

In AP view end on view of index vertebrae is essential, so spinous process can be aligned in disc space.

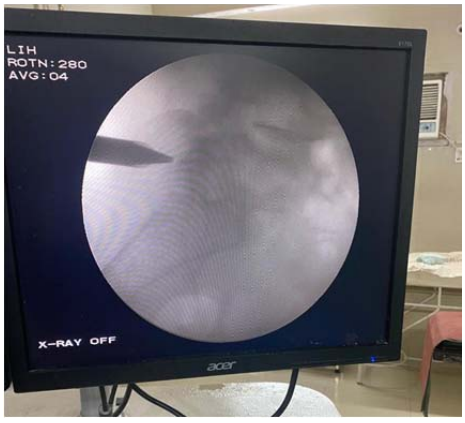
In cases of L5-S1 Disc, a 15 degree tilt of the image collector towards the cranium is required and is called Ferguson's view.

SKIN MARKING – Midline skin marking done and concerned disc space should be marked.

INCISION- 5 to 10 mm Lateral to midline in disc space 6 – 8 mm long incision made.

Placement of dilator – Dilator should be placed on spinilaminar junction of cranial lamina.

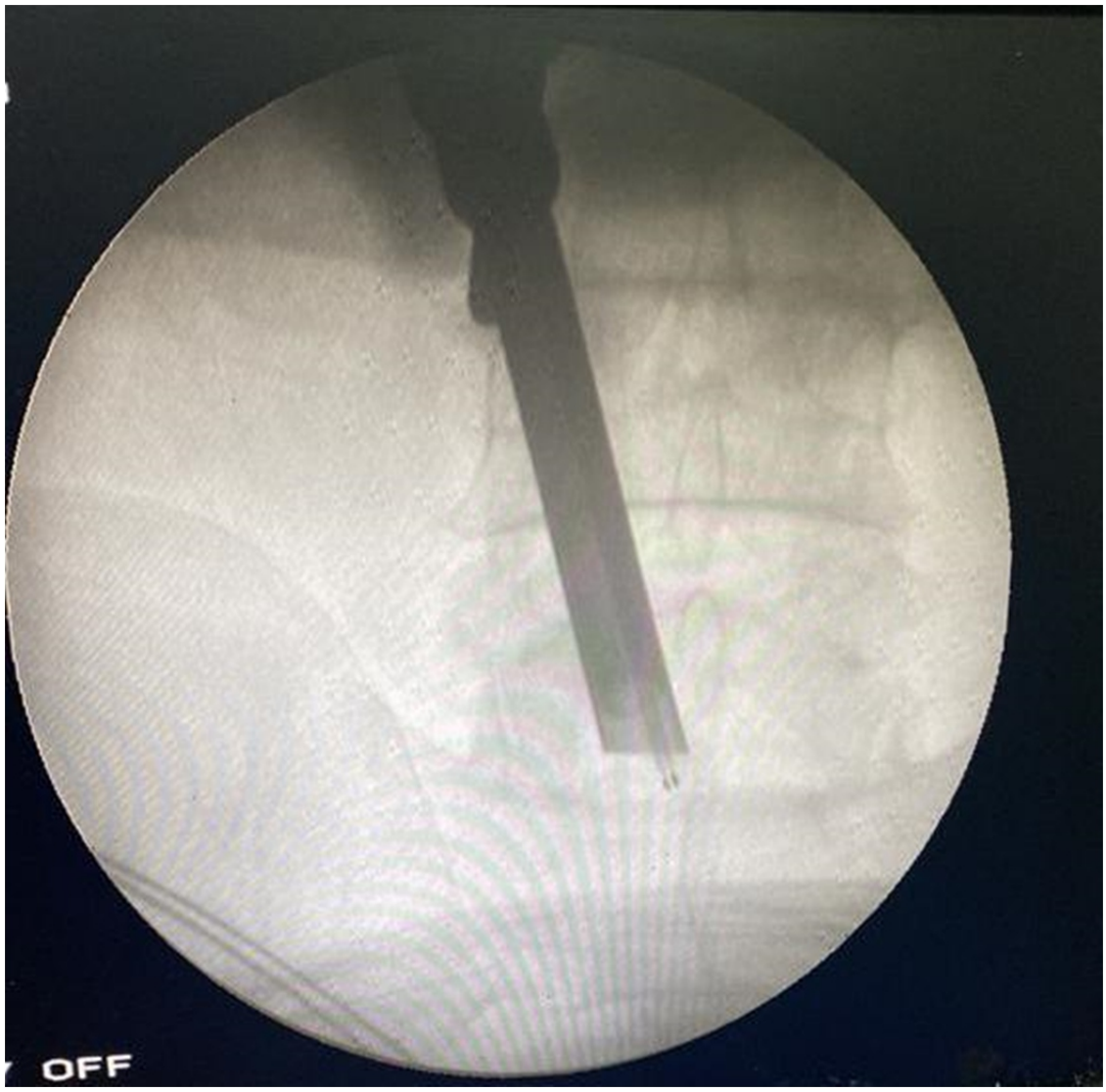
Dilator in AP & LATERAL View L5- S1–



After placing dilator sleeve is inserted then dilator removed and scope placed.

Meticulous hemostasis is obtained through RF probe and edges of lamina removed through BURR and ligamentum flavum removed through kerrison punch.

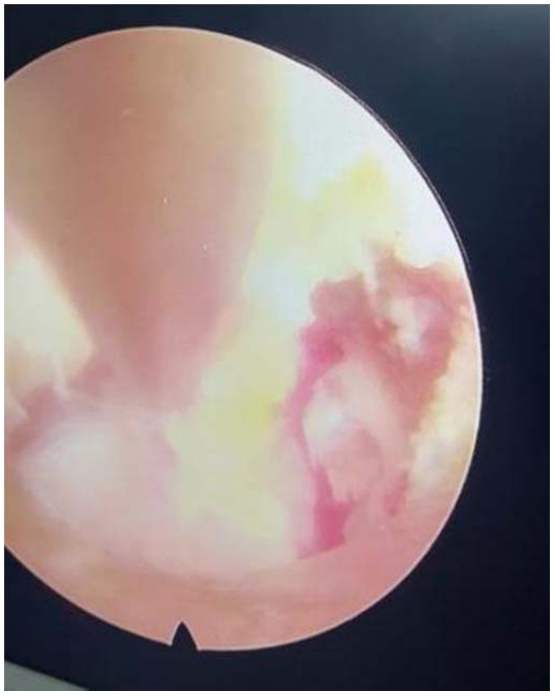
In between position is checked via fluoroscopy.



If disc should be removed then nerve root retractor placed in axillary region and

Traversing root retracted medially and via annulotome disc penetrated then disc fragment removed via grasper.

Image with stenoscope during interlaminar procedure –



In right image yellow structure is ligamentum flavum. In right part flavum is removed in between longitudinal structure is kerrison punch.

After surgery bleeder closed meticulously with RF and 8 no. suction canula placed without vacuum and incision closed with suture or dressing.

Chapter – 8

ADVANCEMENTS IN ENDOSPINE

Recent advancements in endoscopy—

This can be divided in 2 groups first development of new instruments second procedure related.

(A) Development of new instruments -

(1) 3D HD Endoscope & Virtual 3D: 3D Video Converter -

The evolution of endoscopic techniques in spine has largely paralleled the advances in visualization. It started with single-chip camera, then three-chip camera, and now the HD camera image has positively improved the acceptability. The skill of endoscopic spine surgeon is his/her ability to translate a 2D HD image into a mental 3D representation of operative area. The endoscopic spinal surgeon with the help of good HD image overcomes the limitation of 2D image by using visual and tactile cues. The surgeon can use the movements of endoscope in various directions and the instruments to gain motion parallelly with depth cues for 3D perception. The surgeon uses the good quality 2D HD image that lacks 3D image for reconstruction of the anatomy in his/her mind with the use of multiple landmarks. This needs an additional effort that is one of the key factors in steep learning curve.

Use of 3D HD endoscope can be helpful to decrease the steep learning curve in endoscopic spine surgery for new users.

Various technologies are available for 3D endoscopes. One of them is dual optical channel technology. Dual-channel technology incorporates information from two distinct perspectives to get a single 3D view. This is similar to human eye vision. This can be achieved with two separate endoscopes and camera. Also, this can be achieved with two separate video chips incorporated into a single tip. Very subtle differences from two different sources in vertical shift, focus, color balance, and magnification can result in ocular fatigue, headache, and nausea. For this, the endoscope diameter at present is around 10 mm. The conventional “telescope-type” stereoendoscopy with two separate endoscopes does not allow diameters less than 8 to 10 mm. Another available technology is “insect eye” technology or “plenoptic camera.” This

technology uses a single objective lens that splits light into two paths using two pupils, focusing them on to an array of pixels, which are differentiated by a microlens on the top of every pixel pair. These data are processed through a single video source to reconstruct a 3D image. Two separate image sources help in avoiding side effects related to ocular strain, such as headache, nausea, etc **.**

Nerve root view in 3D endoscope –

Virtual 3D: 3D Video Converter -

The virtual 3D is 3D image created from 2D image processing. Two images of right and left are

formed from one image information by calculation using an imaginary conversion angle and

parallax, and then these two images are converted into a single 3D image.

This conversion can be done in real time during endoscopy with M3D-CON (MACHIDA Co. Ltd., Chiba, Japan).

Main advantages of using 3D video converter with endoscopy using M3D-CON are

1. One can get 3D image using any conventional endoscope regardless of diameter, field of

view, view direction, etc., whereas stereoscopic 3D endoscopes are available in diameters

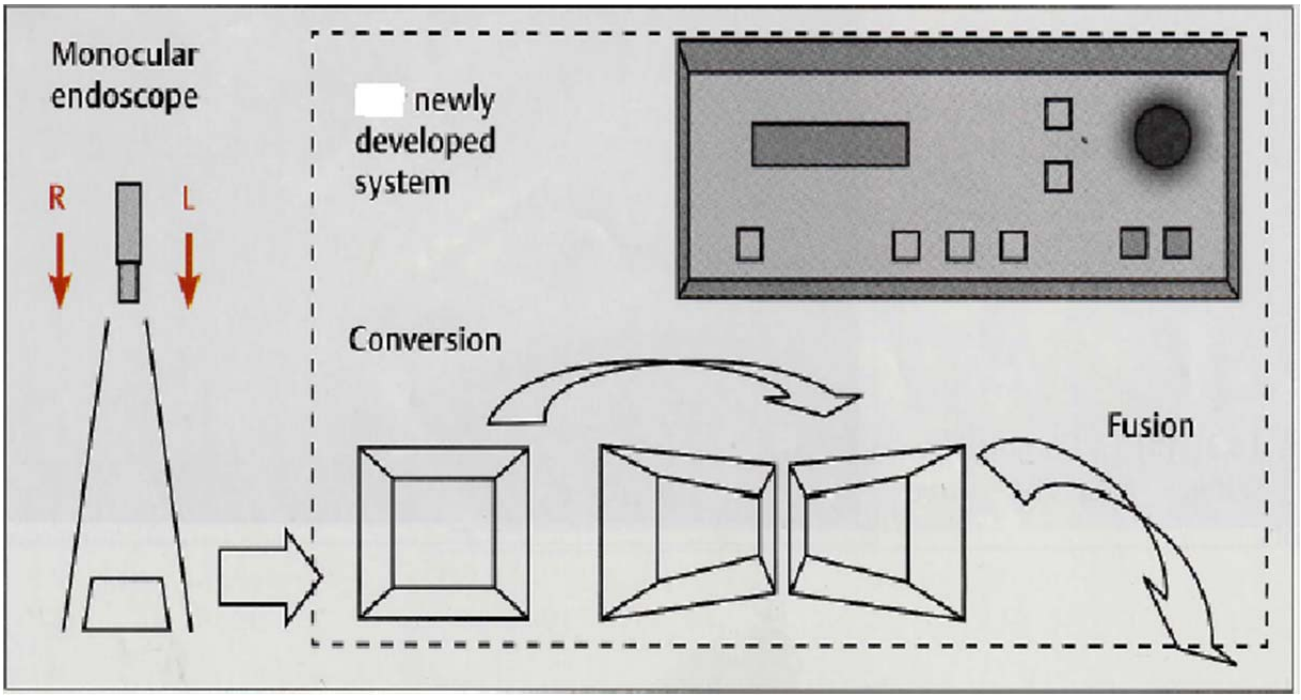
of 4 to 4.7 mm only for spinal and neuro endoscopic techniques.

2. One can do endoscopy just as usual like routine 2DHD endoscopy, whereas 3D stereoscopic

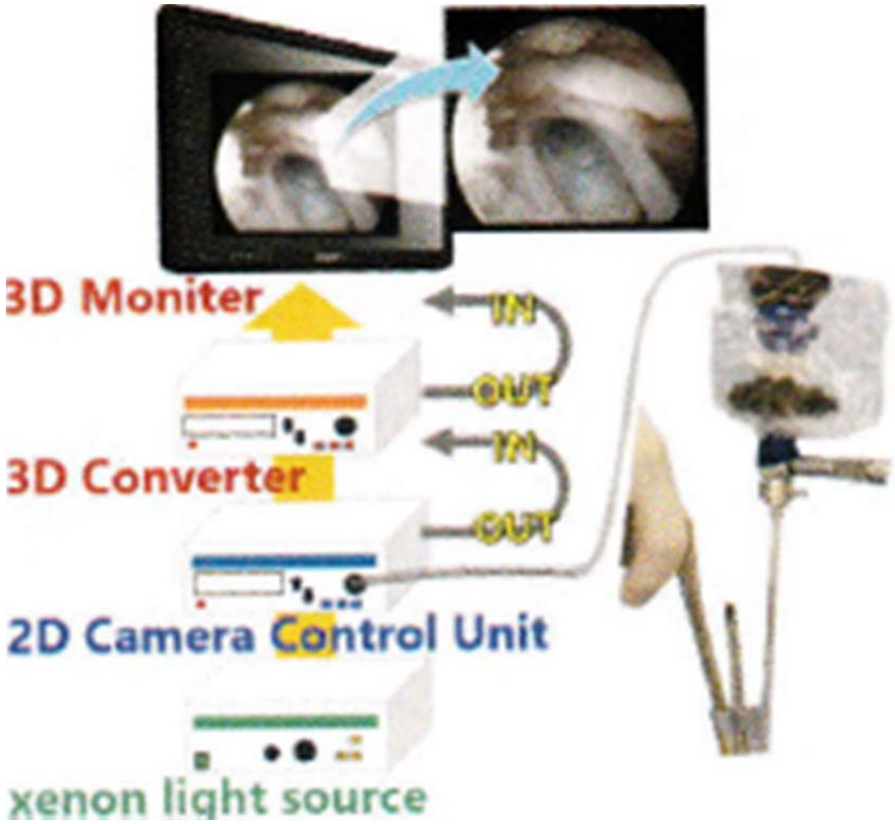
endoscopes need extra efforts for orientation.

3. It is reported that virtual 3D causes less fatigue.

Virtual 3D machenism -



3D video convertor system -



(2) - LASER IN ENDOSCOPIC SPINE SURGERY- Endoscopic spine surgery is greatly aided by the use of lasers, especially the holmium YAG laser. This laser is in the mid-infrared range. It is well absorbed by water and is transmitted through a flexible optic fibre.At 90° side fire, with a 360° rotation capability, it allows you to have precise ablation of the tissue at all angles, as the entry into the disc and the foramen is usually at 35° to 40° and we use at 20° to 30° up looking scope. It is important to have a laser with a 90° side firing capability. (It is actually 70°.)

The holmium YAG laser is a pulsed laser with intermittent firing and therefore produces a minimal amount of heat in tissues. It has the ability to cut, coagulate, vaporise and ablate cartilaginous tissue. It also possesses excellent haemostatic ability at low watts as a result of which, bleeding is not an issue when doing endoscopic spine surgery.

As the holmium YAG laser beam is in the midinfrared zone it is invisible to the human eye therefore, the laser wire usually carries with it a pilot light source which lights the area where the laser will fire and deposit energy causing vaporisation, coagulation and cutting of tissues. This is He-Ne Light. This laser directional light, in advanced machines, can have varying intensities. In case of bleeding tissue with poor

visibility a more bright laser directional light is needed. Laser causes no charring, scarring and evaporates the tissues, there is no residue, so no immunological reaction.

Laser front &back view -

(3) – Navigation in Endoscopic Spine Surgery - Navigation techniques have been employed extensively in spinal instrumentation to reduce radiation exposure, improve accuracy, and avoid iatrogenic injury to nearby critical structures. In endoscopic spine surgery, surgical success relied heavily on accurate localization of instruments, which is technically demanding under fluoroscopic guidance. Various navigation modalities including 3D CT-based, O-arm-based, Ultrasound, and Mixed reality technologies are available nowadays to allow the surgeons to reach the extremely limited surgical field more easily and safely.

Radiation exposure to the surgical team is becoming a great concern in spine surgery, particularly in minimally invasive spine surgery and endoscopic spine procedure, in which intraoperative fluoroscopy was used extensively due to limited surgical field . It has also been mentioned that a spine surgeon performing MIS procedures such as kyphoplasty, when compared with a hip surgeon, will have 50 times greater risk of a fatal cancer .As a result, apart from controlling radiation doses, limiting exposure time, keeping distancing from the source, appropriate shielding, and radiation-free navigation techniques should be considered

Advantages and disadvantages of free hand technique, fluoroscopic guidance, and computerized navigation in pedicle screw insertion.

	Advantages	Disadvantages
Free hand technique	Less surgical time Less radiation exposure Least setup cost	More soft tissue dissection and bleeding Not applicable in those with significant deformity or degeneration
Fluoroscopic guidance	Allow checking of entry site and screw trajectory Readily available in most centers	More radiation exposure Operative field obstructed by the C-arm Sometimes difficult to identify the correct entry point
Computerized navigation	Allow preoperative planning. Operative field free from obstruction by C-arm during screw insertion. Entry site and screw trajectory can be monitored in real time during the whole procedure. More applicable in those	Higher cost related to equipment, operation personnel, and instrument More radiation exposure to patient

Compared with traditional open approach or minimal invasive approach using tubular retractors, endoscopic spine surgery, using subcentimeter wound, allows even less tissue dissection, muscle trauma, blood loss, epidural fibrosis, or scarring, which leads to better functional recovery, reduced hospital stay, and improved quality of life .

In contrast with open or microscopic spine surgery, which allows direct visualization of spinal anatomy, endoscopic spine operation relies on indirect visualization through the endoscope . The field of view during the procedure is therefore markedly limited. Hence, accurate localization of the endoscope and the instruments are absolutely essential so that the exact area of concern can be reached without injuring the critical nearby neurological structures . In addition, precise and real time localization of endoscopy can avoid inadequate or excessive removal of lamina or facet, which can cause iatrogenic instability .

Conventionally, the localization of endoscopy is achieved by fluoroscopy. For example, during transforaminal endo scopic lumbar discectomy, it requires a safe and precise landing of the needle tip into the lower part of Kambin’s triangle, site of

annular puncture at medial pedicular line in AP view and posterior vertebral line in lateral view , in order to avoid injury to the dorsal root ganglion and the exiting nerve root proximally and the thecal sac medially . It requires taking proper AP and lateral views repeatedly and alternatively in order to make sure that the trajectory is correct for the needles and then for the endoscope and instruments, as 2D images are used to estimate the 3D location. This also involves adjusting the C-arm rotation, tilt, and wag nearly every time we change from AP to lateral or lateral to AP view . Therefore, radiation exposure to the operating personnel could be excessive, particularly for both hands . Besides, it constitutes for the steep learning curve in endoscopic spine surgery , It has been shown that in transforaminal endoscopic lumbar surgery by beginners under navigation, the operation time, preoperative location time, puncture channel time, and fluoroscopy times were significantly reduced, compared with conventional technique using fluoroscopic guidance. The learning curve was able to be reshaped .

Clinical Applications –

In navigation assisted surgery, it allows real-time visualization of spinal anatomy in 3D and three views (coronal, axial, and sagittal). More importantly, the exact and accurate location of the navigated instrument inside the spine could be readily assessed for proper localization of the guide pin and avoid injury to surrounding critical structures. Well before the surgery, CT images can be transferred to the navigation workstation so that the surgeon can appreciate the anatomy and plan the optimal trajectory. Precise preoperative planning is particularly helpful for difficult and dangerous anatomical regions. Therefore, apart from classical

transforaminal and interlaminar discectomy in lumbar spine, those spinal areas previously regarded as unsafe for endoscopic surgery can now be assessed with satisfactory results.

In the cervical spine, navigated endoscopic procedures were used for discectomy through posterior foraminotomy and for odontoidectomy under endonasal approach for patients with significant basilar invagination .

transforaminal and interlaminar discectomy in lumbar spine, those spinal areas previously regarded as unsafe for endoscopic surgery can now be assessed with satisfactory results.

In the cervical spine, navigated endoscopic procedures were used for discectomy through posterior foraminotomy and for odontoidectomy under endonasal approach

for patients with significant basilar invagination. Thoracic spine endoscopy is not familiar and considered to be a difficult region to spine surgeons because of the low incidence of disease and the challenging anatomical features, which include the narrowest spinal canal diameter among the whole spine, limited blood supply to the thoracic cord especially over the watershed area at the upper thoracic segments, presence of lungs, heart, and major vessels . With advancement in navigation techniques that allows safe and accurate placement of instruments, indications for thoracic endoscopic procedures have been expanding from soft disc herniation to excisions of hard disc, ossification of posterior longitudinal ligament , drainage and debridement of spondylodiscitis , and osteoid osteoma excision .Navigation techniques are being utilized widely in lumbar spine endoscopic surgeries with promising results.

Clinical examples include transforaminal lumbar decompression over L5/ SI with high iliac crest. The critical factors in surgical success are the location and inclination of the working cannula toward the pathology, taking the height of the iliac crest and the location of disc into considerations . With preoperative planning of endoscopy entry point, trajectory, and the target, we can decide whether the current approaches using either suprailiac or transiliac are feasible. If not, the whole surgical plan can be changed to miniopen or open surgery well before the operation rather than struggling or converting from endoscopic approach intraoperatively .

Highly migrated disc excision would be another surgical entity that can highlight the beauty of navigated endoscopic surgery. Complete removal without complications is challenging, because these herniation are hidden by anatomical structures including pedicle, hypertrophied facets, and ligaments surrounding the neuroforamen. Traditionally, it is regarded as a nightmare for endoscopic spine surgeons due to a high failure rate of up to 15.7% . Semirigid curved forceps are also used to pass through the anatomical barriers . Therefore, navigation-assisted endoscopy can help to overcome these difficulties by determining the feasibility of different approaches preoperatively and accurately executing the planning intraoperatively .

Apart from decompression alone, spinal endoscopy has also been combined with minimal invasive spine transforaminal lumbar interbody fusion technique to become what we called Endo LIF or Endo-TLIF.

On the other hand, in all endoscopic spine surgery, removal of soft tissues including disc or ligamentum flavum is required for decompression of neural structures. However, we are only able to navigate with reference to bony structures.

With the success of CT-MRI coregistration in cranial and spine tumor resection , this special technique can become a solution to reliably locating difficult pathologies like extraforaminal or sequestrated disc herniation . Radiation exposure to the operating personnel could be minimized, because there is no need for any fluoroscopy.

Navigation Modalities -

3D Computerized Navigation -

3D computerized navigation is the most commonly employed technique nowadays. There are numerous systems available in the market, which include intraoperative computed tomography (CT)-based Airo (Mobius Imaging, Shirley, MA, USA) with navigation software (Brainlab, Munich, Germany), cone beam-based CT platforms such as the O-arm with associated Stealth Station (Medtronic, Minneapolis, MN, USA), and the C-arm-based Ziehm Vision FD Vario 3-D with open navigation software integration capabilities (Ziehm Imaging, Orlando, FL, USA) or using with Stryker Navigation (Kalamazoo, MI, USA)

There are a number of systems available, but their basic principles remain the same, which include image acquisition and processing, referencing system, and tracking system . A dynamic reference array is securely fixed onto the patient, either in the form of bony anchor or a newly invented nontraumatic adhesive tracker .It serves to provide information about the 3D relationship between the patient's anatomy and the reference array; therefore, it has to be left undisturbed during the surgery. High-quality images for navigation can be obtained preoperatively or intraoperatively, and they are transferred to the processing unit. The anatomical details of the images have to be accurately matched with the anatomy of the patient on table. It can be done by synchronization of the dynamic reference array while capturing intraoperative images or registration using point and surface matching method . The tracking system helps to localize the reference array and the navigated instrument so that the navigation workstation can calculate and provide real-time 3D positional data of the patient's anatomy and the instrument.

Ultrasound - Ultrasound-guided endoscopic spine procedures have been described in the literature. It offered real-time guidance while inserting the needle or endoscope, therefore reducing the chance of iatrogenic injuries to nerve roots or cauda equina. Besides, radiation exposure should be theoretically reduced to zero, which is particularly suitable for pregnant ladies or young patients with fertility concerns.

However, the accuracy of navigation is operator dependent and one additional experienced sonographer or radiologist is required during the procedure. The clinical results in terms of VAS scores were similar when comparing ultrasound- and X-ray-guided percutaneous endoscopic lumbar discectomy procedures

Mixed Reality -

In mixed reality, the real world is combined with the digital elements so that the user can manipulate both physical and virtual items and environment. This technology has been used extensively in the gaming arena for extraordinary visual experience, and it is also becoming more commonly used in the medical field, including surgical simulations training and real life surgery. Apart from minimizing radiation exposure and real-time localization of instruments, mixed reality allows direct visualization of anatomical and pathological structures so that the degree of dissection or decompression can be precisely controlled. In endoscopic spine surgery training, the puncture times, operating time, and fluoroscopy time were significantly lower when compared with traditional fluoroscopic technique. High satisfaction rate was also observed , In a prospective study comparing mixed reality and fluoroscopic technique, the operation time and the radiation exposure were significantly reduced in the mixed reality group, while the improvements in both NRS scores and ODI were the same. However, the incidence of eye fatigue was increased due to the use of optical see-through head-mounted displays

Robotics in endoscopic spine surgery - The growth and uptake of spinal endoscopy outside of Asia and Europe has been relatively slow, due to challenges associated with its steep learning curve and lack of supporting infrastructure. Nonetheless, as the literature continues to reflect the equivalency of endoscopic approaches and traditional open approaches, it is projected that the demand for endoscopic spinal surgery from both physicians and patients alike will grow. In view of these trends, developments that enhance the anatomic accuracy and ergonomics of endoscopic spinal approaches are needed. The synergistic use of robotics and endoscopy may be used to achieve a ‘super-selective’ laminotomy in the setting of lumbar disc herniation, with the relative advantages of each technology serving to minimise invasiveness while enhancing the ergonomics and safety profile of this approach.

Methodology of using robotic assistance in the setting of spinal endoscopy to define a highly accurate laminotomy in the setting of lumbar disc pathology.

Indications

- Lumbar disc herniation.
- Lateral recess stenosis.
- Foraminal stenosis.
- Ideal for pathologies in which precise targeting critical, including cranially or caudally, migrated disc herniations and revision surgery.

Contraindications

- Active infection, including at anticipated site of Schanz pin (engages robotic platform), usually PSIS contralateral to side of approach.

Preoperative Planning

- Careful patient selection.

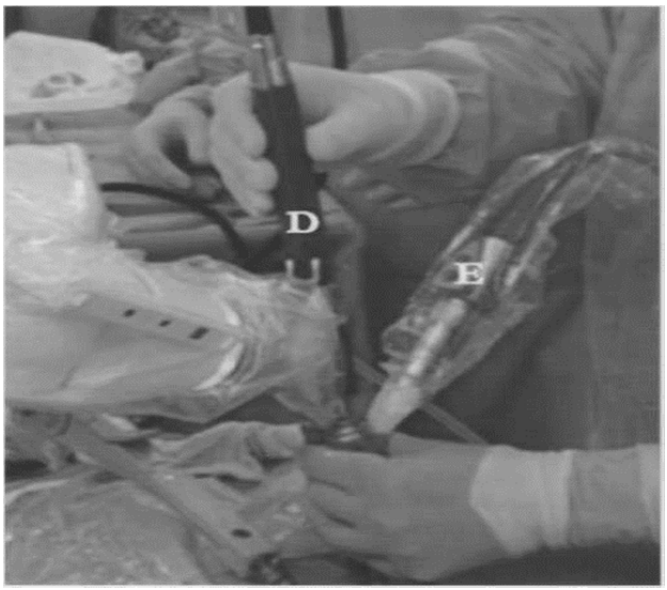
- Availability of equipment, including spinal robot (in this case, Mazor X Stealth Edition, Medtronic, Minneapolis, MN, 55432), intraoperative 3D image acquisition (in this case, O-arm, Medtronic, Minneapolis, MN, 55432) and endoscopic system (in this case, iLESSYS Delta, joimax, Irvine, CA, 92618).

Alternatively, a CT acquired preoperatively can replace intraoperative 3D image acquisition.

Patient and Medical Team Positioning

- Following induction of general anaesthesia, the patient is positioned prone on a Wilson frame, inducing relative kyphosis and opening the interlaminar window.
- To optimise surgical ergonomics, the ideal positioning of the surgeon is ipsilateral to the patient's pathology, while the robotic body is mounted to the bedrail on the contralateral side.
- Intraoperative neuromonitoring is mandatory for transforaminal approaches performed under GA.

Intraoperative image demonstrating the robotic arm in position for a new laminotomy trajectory, and the endoscopic drill being passed down through the custom-made adapter. *Abbreviations: D (drill), E (endoscope)*



In Indian context starting of thoracic and cervical endoscopic spine surgery also can be categorized as recent advancement

(B) - Procedure related advancements – As spine endoscopy progresses new indications develop.

(1) Endoscopic Treatment for Spinal Metastasis - The management of metastatic spine lesions still remains controversial. The goal of surgical treatments of spinal metastases is to achieve decompression of neural elements along with reconstruction and stabilization of the spinal column. Anterior and anterolateral approaches to thoracic and lumbar vertebral metastases are associated with considerable morbidity. Minimally invasive endoscopic approaches have been developed for the surgical treatment of thoracolumbar lesions to overcome the problems associated with anterior approaches. Endoscopic procedures for the surgical treatment of thoracolumbar metastatic spine lesions are being increasingly used. Thoracoscopic procedure provides visualization and magnification of the entire ventral spine from T1 to T12 without the need for open thoracotomy. Interlaminar endoscopic approach and percutaneous transforaminal endoscopic approach are utilized for lesion in the lumbar spine. Minimally invasive endoscopic spinal procedures are reasonable alternatives to treat spinal metastatic disease due to low associated complication rates and short recovery times. The functional and oncologic results are comparable to those of conventional open procedures.

Contraindications-

Patient's comorbidities that represent contraindications for endoscopic approach include pleural adhesions and specific pulmonary conditions that make it unsafe to perform singlelung ventilation. In those patients, thoracotomy or a lateral approach is recommended. In case of a vascular metastatic lesion, preoperative embolization should be considered

(2) Endoscopy in Pain Therapy: Future Applications- Endoscopic approach can be used to have a better detection of anatomical structures in many cases, even if only few approaches have been coded. First of all, it is important to establish that an endoscopic approach can be used to make a nerve stimulation (with pulsed radio frequency) or nerve destruction (with continuous radio frequency), and generally nerve destruction is used in cervical and lumbar facet joint or SI joint neurotomy, where nerve roots can be coagulated without residual functional disability.

In all the other cases, it is not possible to destroy the nerve root, and for this case a nerve stimulation is used, in order to determine a neuromodulation. This technique is commonly used in pain therapy with needle percutaneous approaches with good results, but not long lastin . An endoscopic approach could be useful to be sure of correct nerve detection and stimulation, considering that nerve stimulation has to be really close (1 mm) to nerve root to be effective.

This novel endoscopic approach has been used in suprascapular nerve stimulation in case of shoulder pain . The stimulation probe may be an electro-catheter for suprascapular nerve pulsed stimulation, 40 cm long, with a 1-cm tip stimulating terminal. The catheter is flexible with a rigid metallic guide that is removed before stimulation. The stimulation setting is the pulsed radio frequency using 20-ms stimulation, 480-ms pause, 8 min total, 42 °C temperature, and 45 volts impulse power. Even if the nerve is under the operator's eyes, the electrostimulation gives a better degree of safety. This should provide a radiating pain sensation in the anterior part of the shoulder. The test is considered good when radiating pain was generated at 0.3 mA. In this case nerve detection is made placing the endoscope close to the suprascapular notch. The point of entrance of the endoscope is identified 3 cm below the suprascapular notch to have plane access to minimize the risk of pleural damage. When the endoscope is placed, it is quite easy to detect suprascapular nerve and to proceed to a neuromodulation with pulsed radio frequency with considerable and

stable pain relief.

(3) - Endoscopic Treatment of Spinal Tuberculosis - Spinal tuberculosis (Pott's disease) is the primary finding of tuberculosis in the spine or its dissemination to other sites. This disease is characterized by the destruction of bony structure including the vertebral body and preservation of the disc space as well as back pain, disability, neurologic dysfunction due to nerve sac compression, and instability of the spinal axis . The treatment of spinal tuberculosis depends on the patient's clinical situation; this includes antituberculosis medicine, spinal canal decompression, and surgical stabilization. With the development of endoscopic techniques and high-definition cameras, minimally invasive spinal techniques are improving the efficacy of treating various spinal diseases. Endoscopic treatment for spinal tuberculosis started with simple fragmentectomy of the herniated lumbar disc and the indication is broadened because of the advancement in technology of spinal endoscopy . The unilateral biportal endoscopic (UBE) spinal technique, which uses both endoscopic and instrumental channels, has advantages in bone removal and instrumentation over other endoscopic techniques, and it is expected to treat various spinal diseases with spinal decompression, biopsy, and stabilization with preservation of the muscles.

Indications -

1. Tuberculosis is suspected based on radiologic findings, visible as bone destruction, preserved disc space, and infectious inflammatory findings.
2. Decompression is indicated for symptomatic spinal canal stenosis with granulomatous changes and body destruction.
3. Stabilization is indicated when radiologically confirmed instability is visible with posterior ligamentous complex involvement or symptomatic structural pain.

Contraindications -

1. Extensive multilevel involvement of tuberculosis extending to anterior columns, which anterior or oblique spinal stabilization should be considered.
2. Severe deformity of more than 30° in the Cobb angle.

Transforaminal endoscopy – *Epidural space and paraspinal abscess can be approached via transforaminal approach and can be drained and if required drain can be put in that area.*

UBE -

1. At the decompression site, make two different portals around the interlaminar space: the upper one is the endoscopic portal and the lower one is the instrumental portal (with left-side approach and right-handed surgeon).For the right-side approach for decompression, upper instrumental portal and lower endoscopic portal are made.
2. Incisions can be made either transversely or longitudinally. The transverse incisions are recommended as the fascia and muscle are also cut transversely which can help fluent water flow.
3. After making the 1 -cm portal incisions, the subcutaneous fat and muscle fascia are removed, and a serial dilator is inserted continuously.
4. If a transverse incision is made during decompression, percutaneous screw fixation can be performed using the previous instrumental and endoscopic portals.

Procedure-

1. General anesthesia, spinal anesthesia, or epidural anesthesia should be used depending on the patient's medical condition.
2. The prone position should be assumed for the patient on the spine table, with aseptic dressing over the entire surgical interventional area.
3. Decide the decompression or biopsy procedure level and confirm with portable radiography.
4. The endoscopic portal is made 2 cm upper than the interlaminar space level for right-side approach and 2 cm lower than the interlaminar space if left-side approach is used. Then, a 0° or 12° endoscope is introduced via the endoscopic portal to the interlaminar space level .
5. Muscle detachment should be performed with a specially designed dissector.
6. Under endoscopic guidance, muscle and tissue shaving should be performed by an automated shaver

Finally clinical pain and disability improves, and radiological stability is achieved. The patient is successfully treated with antituberculosis medications.

Special Considerations for L5– S1 Disk Trans foraminal Access

1. In contrast to other lumbar vertebral levels, L5–S1 has unique anatomical limitations: the high iliac crest, the presence of ala, the large facet joint, and the narrow foramen make a percutaneous transforaminal approach difficult.

2. Ebraheim et al analyzed the location of the extraforaminal lumbar nerve roots in relation to the inter transverse space by performing cadaveric dissection. They reported that the L5–S1 level presents difficulty in reaching the L5 nerve root and removing the extraforaminal disk herniation via the narrow intertransverse space due to lordotic curvature and the high iliac crest. Because the extraforaminal lumbar nerve root passes across the disk, one cannot be too careful in attempting to avoid nerve root injury. Ebraheim et al's study showed increases in the extraforaminal nerve root angle and diameter and the distance between the superior facet and lateral limit of the nerve root from cephalad to caudal. The height and width of the intertransverse space were greatest at the L3–L4 level and smallest at the L5–S1 level.

Chapter -9

SPECIAL CONSIDERATIONS FOR L5-S1 DISK HERNIATION

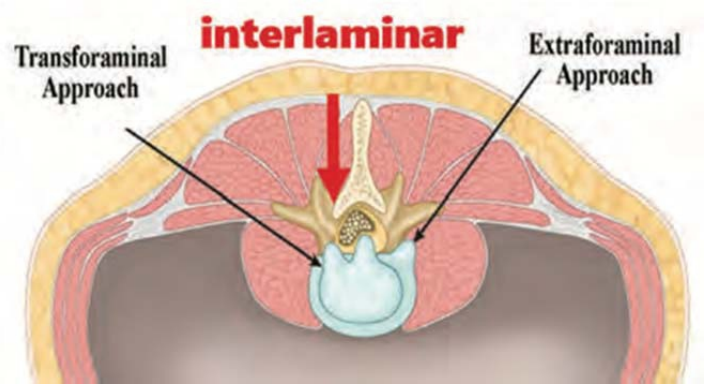
Percutaneous Endoscopic Interlaminar Lumbar Diskectomy: Structural Preservation Technique for L5–S1 Herniated Nucleus Pulposus

Introduction

Microscopic lumbar discectomy has been the standard operation in lumbar disk surgery for herniated nucleus pulposus (HNP), but recently, percutaneous endoscopic lumbar discectomy (PELD) has developed significantly.PELD can be classified into transforaminal PELD (PETLD)and inter-laminar PELD (PEILD) according to the approach. Each method has its own advantages and disadvantages. The indications and anatomical and surgical tips for the two kinds of PELD are discussed in this chapter.

Anatomical Considerations

Classification



	Posterolateral	Interlaminar
Approach	Transforaminal	Trans-shoulder
	Trans-iliac	Trans-axilla
Ligamentum flavum	Spare	Resection or Spare
Annulus repair	Impossible	Possible
Indications	Limited	Wide
Adhesion	Weak	Weak or Strong

Advantages and disadvantages of PELD procedures for L5–S1 HNP

	Shoulder Approach	Axilla Approach
Learning curve	Short	Moderate
Downward migration	Difficult	Easy
Upward migration	Easy	Difficult
Nerve root retraction	Hard	Weak
Annulus sealing	Difficult	Easy

Advantages and disadvantages of two different percutaneous interlaminar approaches

Anatomical Limitations of PETLD and Rationale for PEILD

The condition of the foramen and the iliac crest should be checked before using the transforaminal approach, because in cases associated with a narrow foramen, a shallow suprapedicular area, or a high iliac crest, it will be difficult to approach the target point.

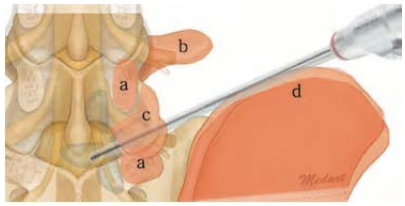


Fig.: Anatomical limitations of percutaneous endoscopic trans- foraminal lumbar discectomy of L5–S1 HNP. a: pedicle; b: transverse process; c: facet joint; d: iliac crest

Fig.: General anatomy of the interlaminar space. (**a**) The L5–S1 level has a wide interlaminar and shoulder space. (**b**) The axillary area is located more cranially than the upper level.

The rationale for PEILD in L5–S1 HNP is shown in the above figure. Anatomical features of the interlaminar space are shown in figure below.

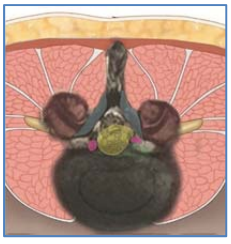


Fig.: Anatomical features of the interlaminar space. a: facet joint; b: ligamentum flavum; c: dura; d: nerve root; e: herniated nucleus pulposus.

Indications and Applications

Recently, the techniques and devices used in PELD have developed significantly. Therefore, nearly all kinds of lumbar disk disease can be treated using PELD, but PELD is not easy to perform due to the steep learning curve, especially in difficult and complicated cases.

PEILD requires a wide interlaminar space. PEILD is especially indicated at the L5–S1 level.

Surgical Procedures

Operating Room Setup

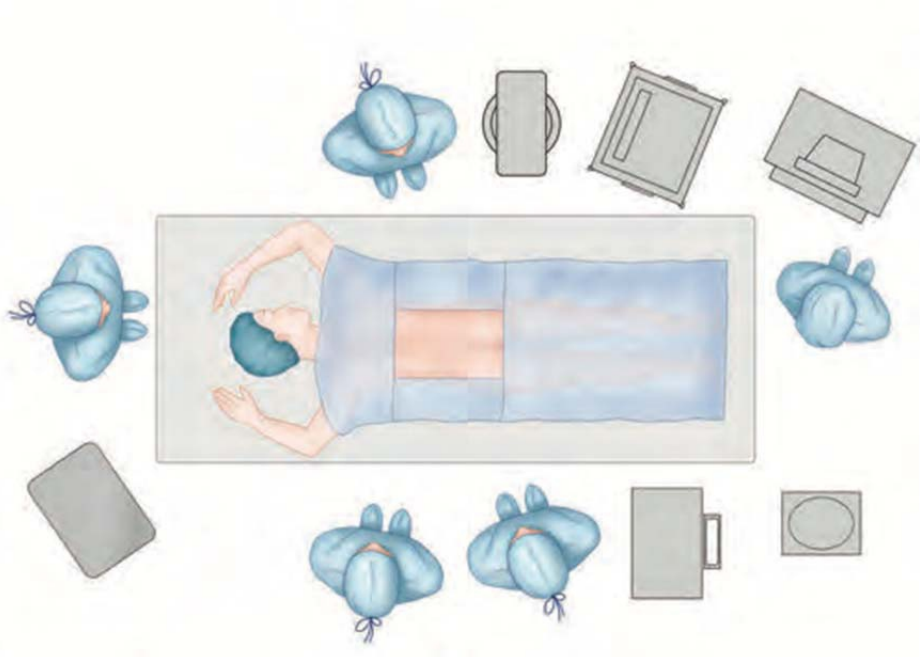


Fig. Standard operating room set-up. A: surgeon; B: nurse; C: anaesthetist; D: X-ray technician; E: technician; F: instrument table; G: C-arm X-ray; H: video equipment; J: image processing; K: suction irrigation equipment.

The above figure shows the standard set-up for the operating room, including the positions of the surgeon, nurse, and instrument table, as well as the positions of the X-ray machine and the video and image-processing equipment.

Anaesthesia

For the interlaminar approach, an epidural block or general anaesthesia is an appropriate choice, because the nerve roots are directly retracted, which causes severe pain. General anaesthesia reduces the patient's anxiety and intraoperative pain, but it lacks the benefit of neural monitoring.

Positioning and Skin Marking

The patient is placed in the prone position for PELD.

Planning the entry point of the working channel is important in PEILD for successful disk removal and for avoiding structural damage, including neural damage. The entry point for PEILD is the "V" point:

- **The V point is the intersection of the ligamentum flavum, inferior articular process, and superior articular process.**
- **Approximately 1 cm from midline of spinous process**

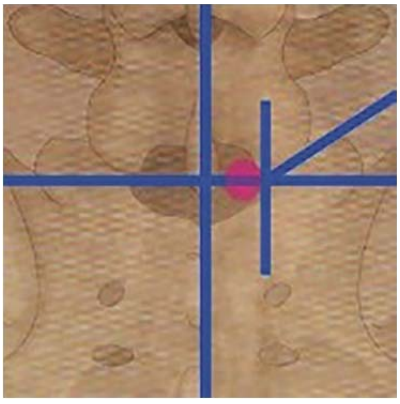


Fig.:V-point(pinkspot): The intersection of the ligamentum flavum, inferior articular process, and superior articular process.

CHAPTER – 10

SPINAL PATHOLOGY DIAGNOSIS

Introduction:

The spine, a marvel of anatomical engineering, is a central pillar of the human body. It provides structural support, enables movement, and houses the delicate spinal cord, a vital conduit for neural communication between the brain and the rest of the body. Yet, like any intricate mechanism, the spine is susceptible to a spectrum of ailments and conditions that can significantly impact a person's quality of life.

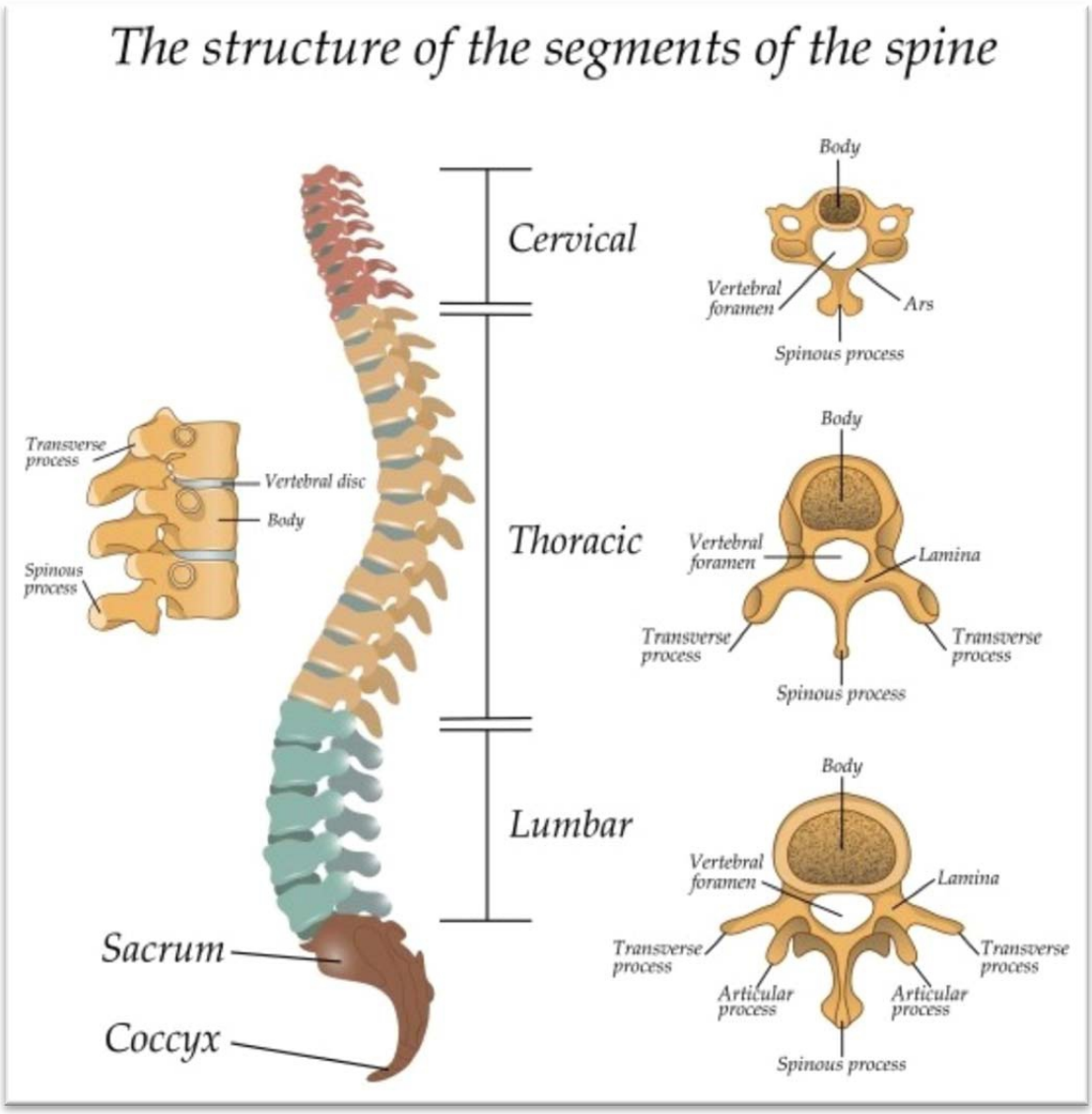
The ability to accurately diagnose spinal problems is a linchpin in orthopaedics and neurology. Timely and precise diagnosis helps alleviate pain and discomfort and plays a pivotal role in charting a course for effective treatment and management. This chapter embarks on a journey through the labyrinth of spinal diagnostics, shedding light on the tools, techniques, and strategies that healthcare professionals employ to unravel the mysteries of spinal conditions.

Anatomy of the Spine:

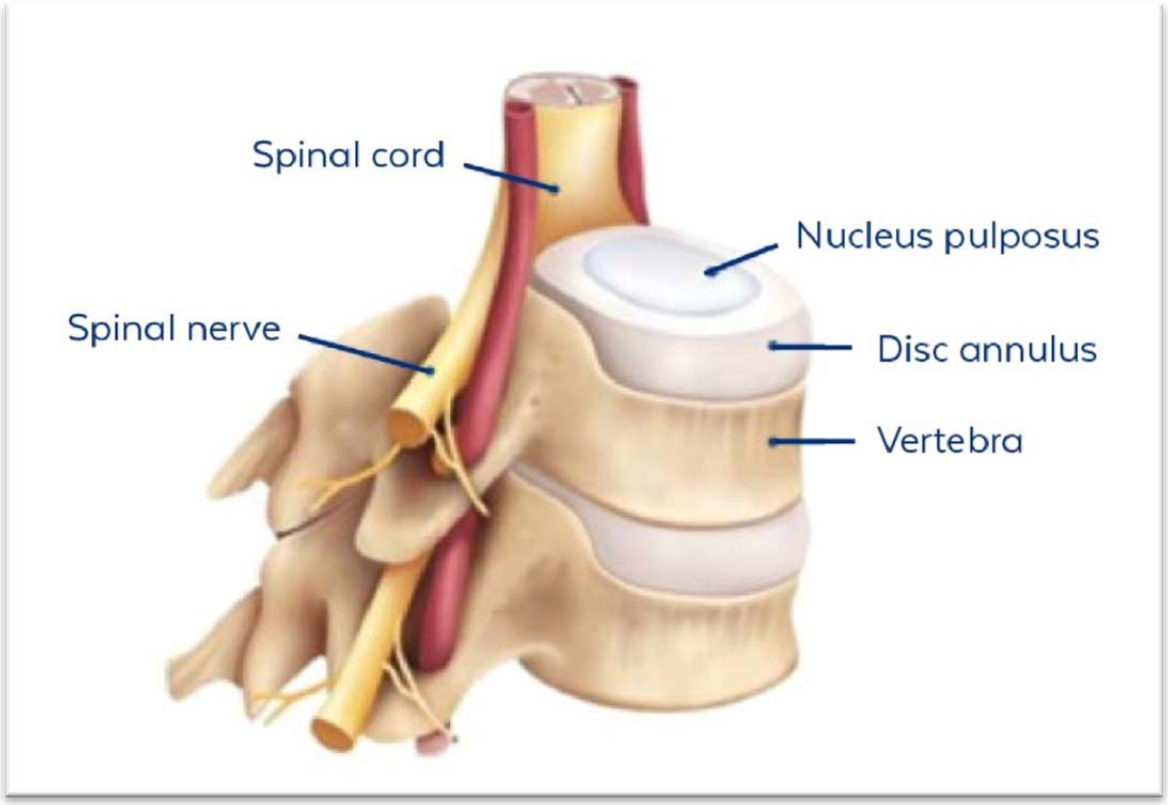
The human spine, often called the vertebral column or backbone, is a remarkable architectural marvel. Comprising a series of 33 vertebrae, it is the central support structure for the entire body while facilitating movement and protecting the delicate spinal cord. Understanding its intricate anatomy is essential for grasping the complexities of spinal diagnostics.

The spine is typically divided into five regions: cervical, thoracic, lumbar, sacral, and coccygeal. The cervical spine in the neck consists of seven vertebrae, followed by the thoracic spine, with twelve vertebrae extending through the upper and mid-back. Below, the lumbar spine is comprised of five large vertebrae in the lower back, supporting much of the body's weight.

The sacral region fuses five vertebrae into a single triangular-shaped bone, forming the back portion of the pelvis. Lastly, the coccyx, the tailbone, is a small, fused structure composed of three to five coccygeal vertebrae.



Intervertebral discs, acting as shock absorbers, sit between most vertebrae, allowing flexibility and cushioning. These discs have a tough outer layer (annulus fibrosus) and a gel-like inner core (nucleus pulposus).

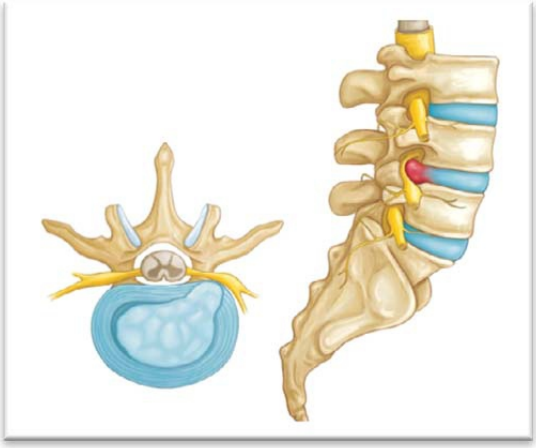


Collectively, the spine's components, including vertebrae, discs, and facet joints, interact seamlessly to provide support, stability, and mobility. Understanding this intricate anatomy is pivotal for diagnosing and treating spinal conditions effectively.

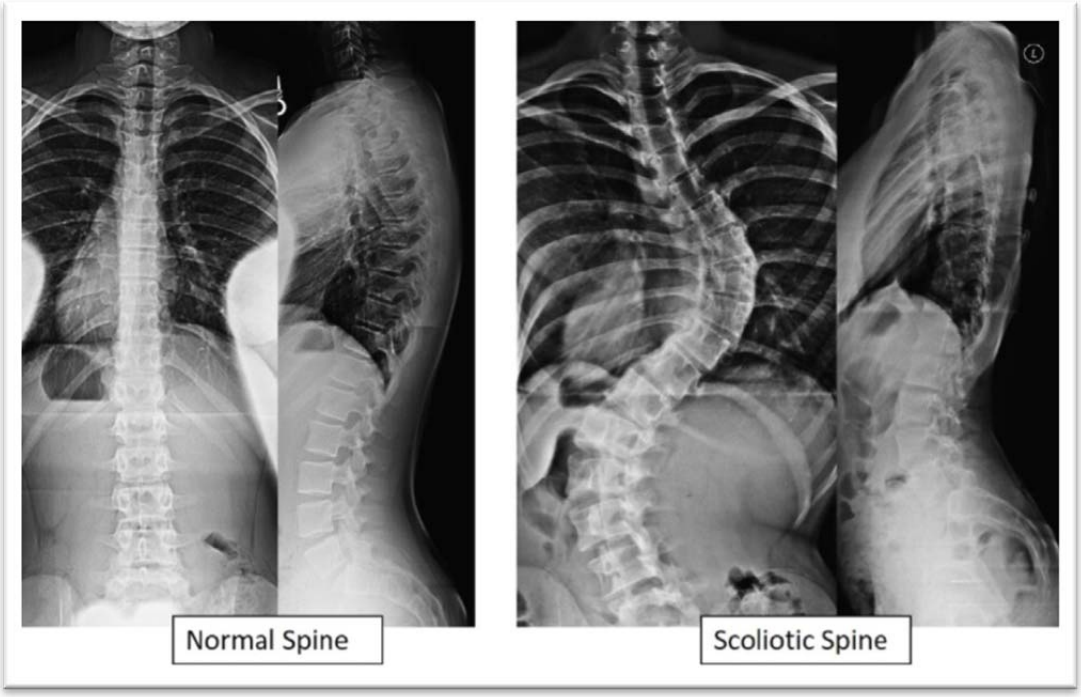
Common Spinal Problems:

The spine, a marvel of design, can nonetheless be vulnerable to various conditions that affect individuals of all ages. Understanding these common spinal problems is crucial for early diagnosis and effective management:

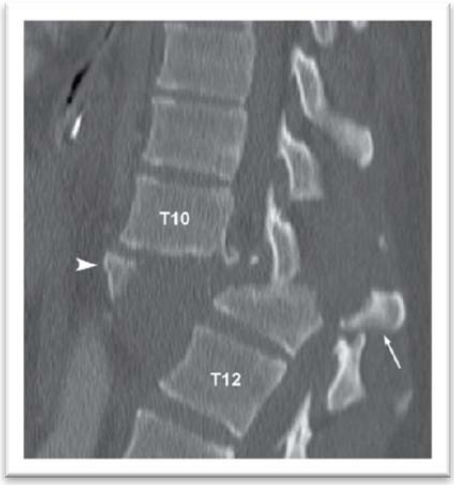
1. **Herniated Discs:** A herniated disc, often called a slipped or ruptured disc, occurs when the soft inner core of an intervertebral disc protrudes through the tough outer layer. This can compress nearby nerves, leading to pain, numbness, or limb weakness. Herniated discs are commonly diagnosed through MRI or CT scans.



2. **Degenerative Disc Disease:** This condition involves the gradual wear and tear of the intervertebral discs over time, causing pain and reduced mobility. Age, genetics, and lifestyle factors contribute to its development. Diagnosis often involves X-rays and discography.
3. Scoliosis is a lateral (sideways) curvature of the spine, which can lead to an abnormal posture and back pain. It's typically diagnosed through physical examination and X-rays. It can be congenital (present at birth) or develop during growth spurts in adolescence.



4. **Spinal Stenosis:** Spinal stenosis refers to the narrowing of the spinal canal, which can compress the spinal cord or nerves, resulting in pain, numbness, and weakness. It often occurs in the lumbar (lower) spine and is diagnosed through MRI or CT scans.
5. **Vertebral Fractures:** Fractures in the vertebrae can result from trauma, osteoporosis, or other medical conditions. They can cause severe pain and height loss. Diagnostic methods include X-rays and sometimes advanced imaging like MRI or CT scans.



6. **Tumours of the Spine:** Spinal tumours can be benign or malignant and may originate in the spine or spread from other parts of the body. They can lead to pain, neurological symptoms, or spinal instability. Diagnosis involves imaging, such as MRI or CT scans, and sometimes biopsy for a definitive diagnosis.

Understanding the symptoms, risk factors, and diagnostic approaches for these common spinal problems is essential. Early and accurate diagnosis is the first step towards effective treatment, whether it involves conservative measures like physical therapy and medication or more invasive interventions like surgery. Each condition presents unique challenges, but with advancements in diagnostic tools and treatment options, individuals facing these spinal problems have a range of strategies available to improve their quality of life and spinal health.

Diagnostic Tools and Techniques:

Accurate diagnosis is the cornerstone of effective management of spinal problems. Healthcare professionals employ various diagnostic tools and techniques to evaluate the spine's condition, identify abnormalities, and develop appropriate treatment plans. In this section, we will explore these essential methods in detail:

Radiological Imaging

Radiological imaging is a cornerstone of spinal diagnosis, providing healthcare professionals with detailed visual information about the spine's anatomy and any potential abnormalities. Several key imaging modalities assess spinal conditions, offering unique advantages and insights.

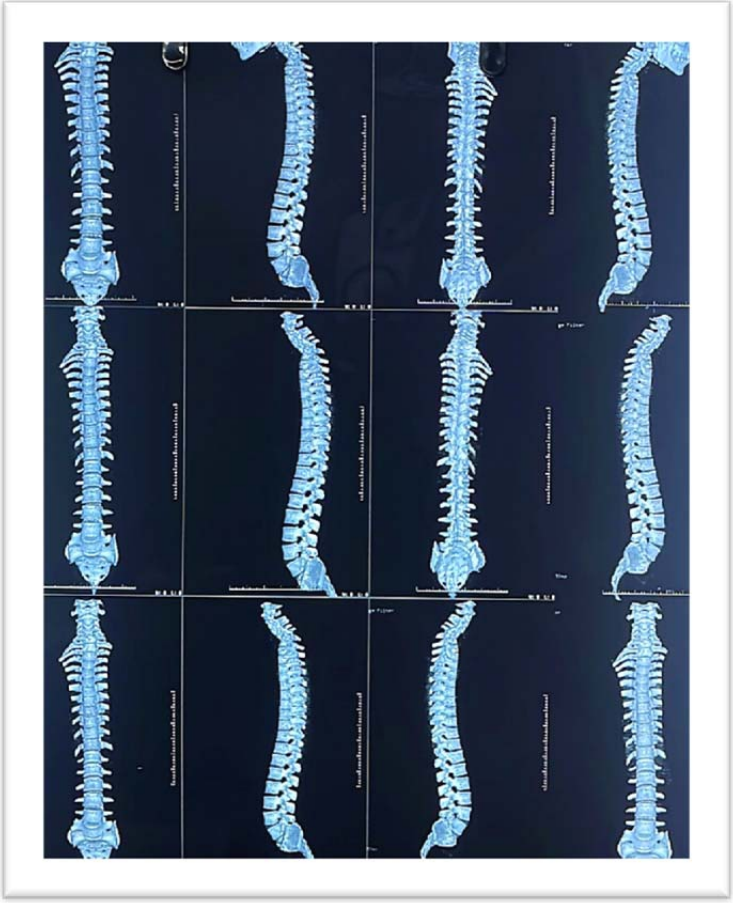
1. **X-Rays:**
    - **Overview:** X-rays are often the first line of diagnostic imaging for spinal problems. They are widely used due to their accessibility, speed, and relatively low radiation exposure. X-rays generate two-dimensional images of the spine, highlighting bone structures and revealing fractures, misalignments, or signs of degeneration.
    - **Usage:** X-rays assess spinal conditions, such as fractures, scoliosis, and osteoarthritis. They are especially effective for detecting structural abnormalities and evaluating bone density.
    - **Procedure:** The patient is positioned between an X-ray machine and a detector or film during an X-ray. A small dose of ionizing radiation is directed through the body, creating an image on the sensor. Radiologists analyze these images to identify any abnormalities.

2. **Magnetic Resonance Imaging (MRI):**
    - **Overview:** MRI is a non-invasive imaging technique that provides exceptional detail of soft tissues within the spine, including spinal discs, nerves, and ligaments. It is the gold standard for diagnosing herniated discs, spinal stenosis, and spinal cord tumours.
    - **Usage:** MRI is used when a comprehensive spinal cord and soft tissue assessment is required. It is invaluable for diagnosing conditions affecting

the spinal discs and spinal cord compression and evaluating the extent of spinal tumours.

- **Procedure:** The patient lies on a movable table inside a large, cylindrical magnet during an MRI. The MRI machine uses powerful magnets and radio waves to generate images. Unlike X-rays or CT scans, MRI does not involve ionizing radiation. Patients are required to remain still during the examination, which may last 30 to 60 minutes.
- **Advantages:** MRI provides exceptional soft tissue contrast and can detect subtle abnormalities that other imaging methods might miss. It is beneficial for assessing neurological conditions and spinal injuries.

3. **Computed Tomography (CT) Scan:**
   - **Overview:** CT scans provide detailed cross-sectional spine images, offering a 360-degree view of bone structures and abnormalities. CT scans are beneficial when assessing complex fractures, spinal stenosis, or evaluating the bony anatomy of the spine.
   - **Usage:** CT scans visualize bone fractures, spinal tumours, and complex spinal deformities. They are also valuable for surgical planning and guiding interventional procedures.
   - **Procedure:** During a CT scan, the patient lies on a table that moves through a doughnut-shaped machine. X-ray beams rotate around the body, capturing multiple cross-sectional images. A computer assembles these images into detailed, three-dimensional views. CT scans involve a higher dose of ionizing radiation compared to X-rays.
   - **Advantages:** CT scans provide excellent bone detail and are often used in trauma cases or when fine anatomical information is critical for diagnosis or treatment planning.



4. **Myelography:**
   - **Overview:** Myelography is a specialized imaging procedure to visualize the spinal cord and nerve roots within the spinal canal. It is precious for diagnosing spinal stenosis, nerve compression, or arachnoiditis.
   - **Usage:** Myelography is typically employed when other imaging methods, such as MRI or CT, do not provide sufficient information. It helps identify the precise location of spinal cord or nerve compression.
   - **Procedure:** In myelography, a contrast dye is injected into the spinal canal through a lumbar puncture (similar to a spinal tap). This dye enhances the visibility of the spinal cord and nerves during subsequent X-rays or CT scans.
   - **Advantages:** Myelography can provide valuable information about cerebrospinal fluid flow dynamics and any compressive lesions within the spinal canal.

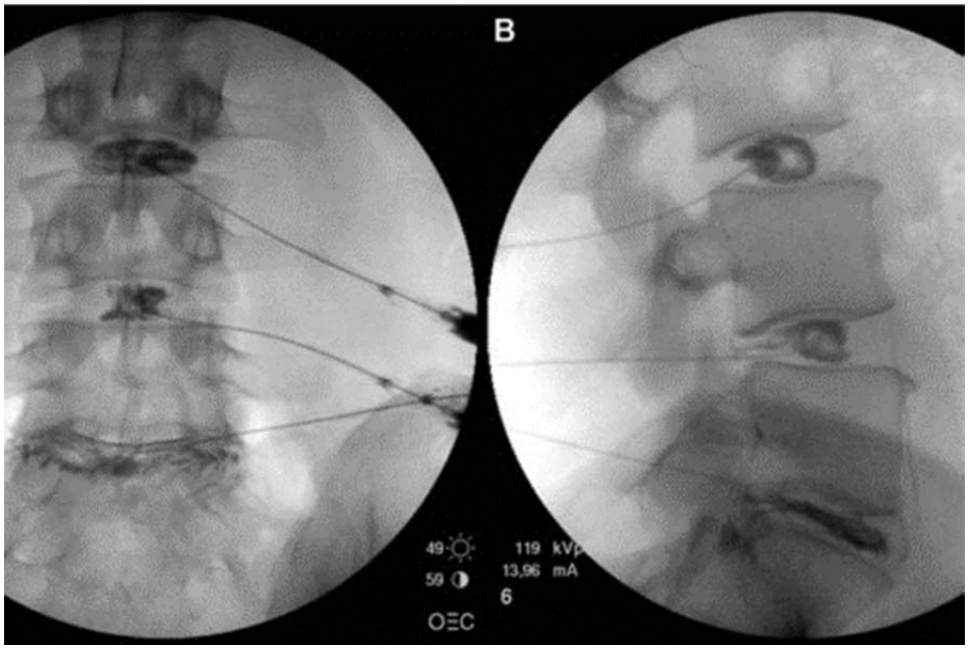
Choosing the appropriate imaging modality depends on the clinical presentation, suspected spinal problem, and the information needed for diagnosis. These radiological imaging techniques, when used judiciously, help healthcare professionals pinpoint the location and nature of spinal abnormalities, facilitating prompt and accurate treatment decisions. Additionally, imaging technology advancements continue to enhance the precision and diagnostic capabilities of spinal care.

2. **Physical Examination:**

- Clinical Assessment: A thorough physical examination by a healthcare provider is essential to spinal diagnosis. It involves assessing the patient's posture, range of motion, muscle strength, and reflexes. Specific clinical tests, such as the straight leg raise test for sciatica or Spurling's test for cervical radiculopathy, can help identify potential spinal issues.
- Neurological Examination: Neurological assessments evaluate sensory perception, motor function, and reflexes. Abnormalities in these areas can provide valuable clues about the location and nature of a spinal problem.

3. **Advanced Diagnostic Procedures:**

a. Discography: Discography involves the injection of contrast dye into one or more intervertebral discs to assess their integrity and identify the source of pain. This procedure is typically used when other imaging methods are inconclusive and the patient experiences chronic, unexplained back pain.



b. Bone Scans: Bone scans can detect changes in bone metabolism and help identify conditions such as metastatic tumours, infections, or fractures that may not be visible on X-rays or CT scans. A small amount of radioactive material is injected into the bloodstream, and a special camera detects its accumulation in affected areas.

c. Electromyography (EMG) and Nerve Conduction Studies (NCS): EMG measures electrical activity in muscles, while NCS assesses how well nerves transmit electrical signals. These tests can help diagnose nerve-related spinal conditions like radiculopathy or peripheral neuropathy.

d. Biopsy: In cases of suspected spinal tumours or infections, a biopsy may be necessary to obtain a tissue sample for examination. Biopsies can be performed using imaging guidance to ensure accuracy.

e. Genetic Testing: In rare cases, genetic testing may be warranted, especially when hereditary conditions like spinal muscular atrophy are suspected. Genetic tests can confirm a diagnosis and provide valuable information for treatment planning.

4. Clinical History and Patient Interviews:

a. Gathering a comprehensive clinical history is a vital component of spinal diagnosis. Patients are typically asked about their symptoms, the onset of pain or discomfort, any relevant medical history, family history of spinal problems, and lifestyle factors such as occupation and physical activity.

5. Pain Mapping:

a. Pain mapping techniques may be employed for individuals with chronic or complex pain. These involve carefully assessing the location, intensity, and radiation of pain to pinpoint the source and nature of the problem. Pain mapping can guide treatment decisions, such as targeted injections or surgical interventions.

6. **Functional Assessment:**
    a. Functional assessments evaluate how spinal conditions affect an individual's daily activities, mobility, and overall quality of life. These assessments can include questionnaires, self-reported pain scales, and objective measures of physical function.
7. **Multidisciplinary Approach:**
    a. In many cases, a multidisciplinary team of healthcare professionals collaborates on diagnosing and treating spinal problems. This team may include orthopaedic surgeons, neurosurgeons, physiatrists, physical therapists, pain management specialists, and radiologists. Their combined expertise ensures a comprehensive evaluation and personalized treatment plan.

It's important to note that choosing diagnostic tools and techniques depends on the specific spinal problem, the patient's symptoms, and the healthcare provider's clinical judgment. The goal is to tailor the diagnostic approach to each individual's needs to achieve an accurate diagnosis and initiate appropriate interventions, whether conservative measures, minimally invasive procedures, or surgical intervention. Spinal diagnosis is a dynamic and evolving field, with advancements in technology and techniques that continue to enhance our ability to understand and address spinal issues effectively.

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