SAMPLE CONTENT

# HUMAN SPINE AND PEDICLE SCREWS

## LEARNING TECHNOLOGY OF PEDICLE SCREW INSERTION LUMBAR, THORACIC, CERVICAL AND CVJ


Chief Editor
**Prof. P. S. Ramani**

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# PROLOGUE

**Dr. P. S. Ramani**

Spinal surgery is in its nascent form, compared to its predecessors, such as general surgery, several centuries older.

Although Mixter and Barr were the first to perform a laminectomy for a prolapsed inter-vertebral disc in 1932, it was in 1934 that they presented a series, co-relating clinical syndrome and radiological and surgical findings.

I take pride in the fact that the advent of spinal surgery and I are contemporaneous;I being born four years later.

Mixter and Barr's first laminectomy involved the L1-S2 for prolapse of lumbar inter-vertebral disc at level 1. However, following close on its heels was an influx of comprehensible cognition of the functioning of the spine, and its biomechanics with a simultaneous and unprecedented boom in the market of machinery. Innovations like the microscope, bipolar coagulation, refined instruments and implants, resulted in spinal surgery becoming minimally-invasive through endoscopic and then percutaneous procedures,over a short period of time.

In all the global progress on spinal surgery, the pedicle screw is the most commonly used device among spinal surgeons. It would be conducive to budding and potential surgeons in this field of surgery, if they were to have an in-depth knowledge of the pedicle screw and its insertion into the human spine, before attempting any surgical procedure.

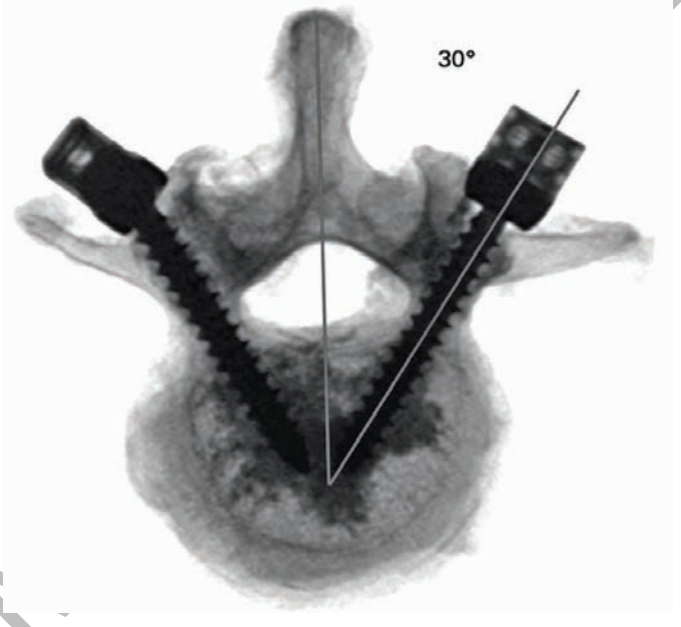
This book there for is an attempt to provide a brief,but necessary source of information on pedicle screws in various levels in the spine. It is my sincere desire to provide a teaching guide for young, aspiring spinal surgeons,who will doubtlessly be attending to many such surgical procedures-during the course of their career.

My best wishes go out to them.

**Dr. P. S. Ramani**

# SECTION I

## UNDERSTANDING PEDICLE SCREWS




1. Bio-mechanical properties of pedicle screws- Dr. Ram Chaddha.
2. The present system of pedicle screw instrumentation- Dr. Ritesh Nazareth.
3. The overall strength of the pedicle screw- Dr. Shradha Maheshwari.
4. Complications in pedicle screws- Dr. P. S. Ramani, Dr. Apurva Prasad.

# BIO-MECHANICAL PROPERTIES OF PEDICLE SCREWS

**Dr. Ram Chaddha**



## Introduction

The posterior pedicle screw-based instrumentation is a fixator-distractor-compressor-derotator system. It is modular, simple and has a three dimensional correction capacity, precisely matching the patient. It is the unique screw design that provides strength.

The rationale of its use is based on safely controlling the anterior and middle column via the posterior column, through a channel by which the forces from the posterior are transmitted to the vertebral body. This point is called the "'force nucleus,'", which is the confluence of five anatomic structures; the superior facet, the inferior facet via the pars, the lamina, the pedicle and the transverse process. The localization during surgery is the convergence of the ridges of the pars, superior facet and transverse process. A "channel" or "window" is created which is an intra-medullary canal of the pedicle for the screw.

The principle on which the assembly works, is the fact that the Spinal Fixator has two elements:– the screws and the spacers. The screws are implanted in the vertebral body via the pedicle, while the spacer is a plate or a rod. The spacer acts as like a bridge, or as a compressor or distract or between the screws.

## Biomechanics of the pedicle screw

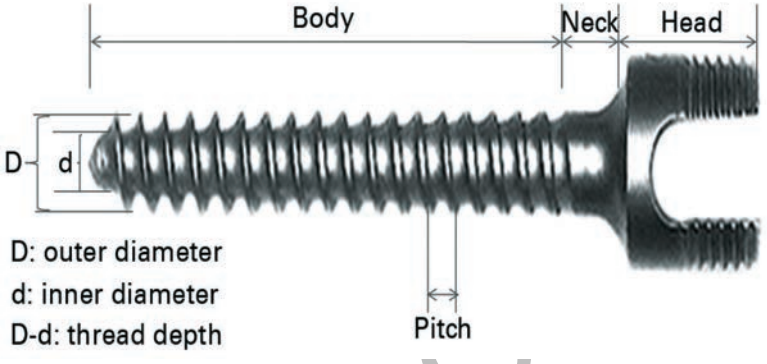
- **Screw Characteristics**
- **Insertion Technique**
- **Augmentation/Salvage**

## Screw Characteristics

The screw consists of a head, neck and body.

The body may be conical or cylindrical.

It has a major (outer) and minor (inner) diameter. The difference between the two is the thread depth. The pitch of the thread is the distance between the crests of two adjacent threads.




## Pullout Strength

It is generally thought that a larger outer diameter, a smaller inner diameter, shorter pitch, and stronger bone increase the pullout strength.

Among them, the outer diameter is the most important factor in determining pullout strength.

The morphology of the pedicle also affects the pullout strength of the screw.

About 60% of the screw pullout strength and 80% of the longitudinal stiffness depend on the pedicle, rather than the vertebral body.

In osteoporosis, however, the cortex of the pedicle is thinner and the bone mineral density (BMD) is reduced. The use of a larger screw does not increase the stability of the construct and may result in cortical cut out, or fracture of the pedicle.

## Insertional Torque

Many surgeons prefer a pedicle screw with high insertional torque, because it gives good tactile feedback of bony purchase.

Although there is a strong correlation between insertional torque and BMD, screw loosening is not objectively predicted by insertional torque in the clinical setting.

The insertion torque is very sensitive to thread design, while the pullout strength is not.

Fatigue Strength:

The inner diameter is the most important dimension of the pedicle screw when considering its fatigue strength.

The neck is the weakest part of a monoaxial screw and the coupling between the polyaxial head and the screw is its weakest part.

### Different Designs

Bushing augmented screws, in order to improve load-bearing capacity, Screws with dual core, in which the inner diameter thickened around the neck to improve fatigue strength and double threaded screws to facilitate faster insertion - all yielding promising biomechanical results.

Double lead and dual thread near the pedicle area can provide higher insertional torque.

The inner core of the pedicle screw can be conical or cylindrical. In terms of insertional torque, the conical screw is superior, but the pullout strength is the same. However, the conical screw will loosen if backed out for 360°.

## Insertion Technique

### Screw Hole Preparation:

When inserting pedicle screws, keeping the dorsal cortex intact is important for solid fixation.

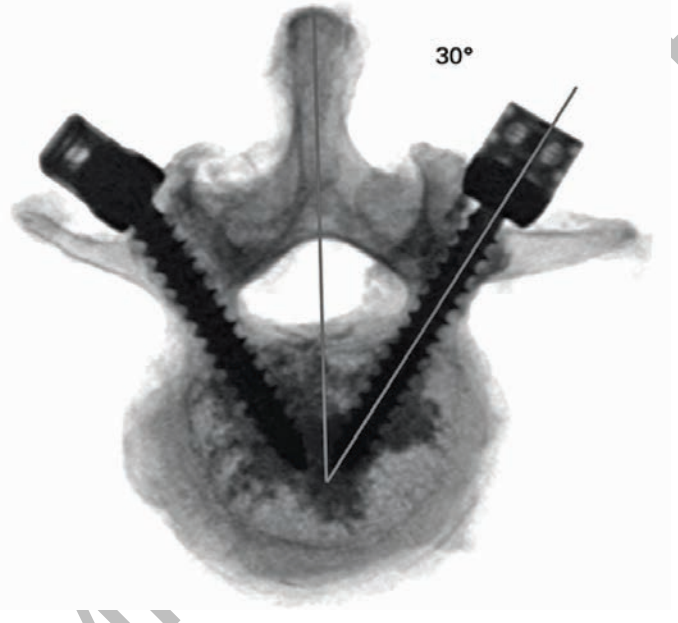
Tapping improves trajectory. However, screws placed into untapped holes have a higher pull out strength. Generally, same-size tapping is not recommended, as it reduces the purchase of the screw, but under tapping by 1 mm is thought to be safe and conserves the same pull out strength as an untapped screw hole.

The most important point is not to manipulate the screws

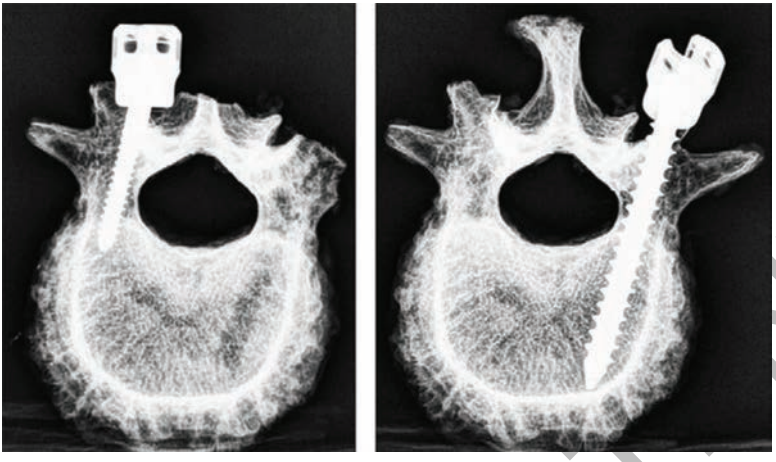
excessively, because insertion, back-out, and reinsertion of the screws lead to a decrease in insertional torque and pullout strength.

## Trajectory:

Convergence of pedicle screws by 30° in the coronal plane can increase the pull out strength. Insertion of the screws without convergence, however, is more stable in terms of longitudinal linkage.




More recently, a laterally-directed cortical bone trajectory was advocated and was found to have similar biomechanical characteristics to the more traditional medial trajectory. This cortical trajectory is especially effective in poor trabeculated, osteoporotic bone.



### Insertion Depth:

About 80% penetration depth, or passing the neurocentral junction is considered sufficient.

## Augmentation/Salvage:

### Indications & Options:

Augmentation can be used for revision, or in severely osteoporotic patients, including cement augmentation, additional hooks and wires, and larger expandable or hydroxyapatite-coated screws. Recently, other options such as extra-pedicular screws, double pedicle screws, and injection cement, through an appropriate implant have been advocated.

Larger screws haves higher construct stiffness than the PMMA-augmented screw. The pull out strength is improved if the screw is inserted while the PMMA is in its doughy state, rather than after it has hardened. The development of bioabsorbable cement, which has the same favourable biomechanical properties and high osteo-conductivity while discharging less heat than PMMA, is a step towards further improvement.

## Pedicle Screw Constructs:

### Pedicle screw constructs versus other constructs:

Posterior pedicle screw fixation with anterior plating and a strut

graft, gives the most rigid fixation. Less rigid constructs were posterior pedicle screw fixation with anterior strut grafting, but without plating, followed by posterior pedicle screw fixation alone and then anterior plating with a strut graft.

Pedicle screws alone do not provide sufficient stability if the anterior column is compromised.

Biomechanical properties of different pedicle screw constructs:

Extending the construct by one more level above and below, the mean ROM across the pathological level was decreased by 56%. Screws angled cephalad developed a greater mean intrapedicular bending moment when compared with screws inserted caudal or parallel to the superior end plate. This suggests that cephalad insertion should be avoided, because of an increased risk of early fatigue or failure. The axial insertion angle was also studied: straight screw insertion with no convergence provided a more stable longitudinal construct.

### New pedicle screw constructs:

Newer materials including PEEK – *poly ether ether ketone* rod system and perpendicular plate system are still to prove clinical efficacy.

### Insertion technique of transverse connectors:

Only axial rotational stability improves significantly with the addition of transverse connectors. The greatest stability can be obtained with two transverse connectors :- one in the middle and the other at the proximal 1/8 position of the longitudinal rods.

### Indication for transverse connectors:

In all cases of anterior column instability, including fracture, anterior discectomy, or anterior corpectomy, and when correcting rotational deformity.

## Conclusion

The outer diameter of the screw determines pull out strength, while the inner diameter determines fatigue strength.

When inserting a pedicle screw, the dorsal cortex of the spine should not be violated and the screws on each side should converge and be of good length. Thirdly, fixation can be augmented in cases of severe osteoporosis or revision.

A trajectory parallel or caudal to the superior end plate can minimise breakage of the screw from repeated axial loading. Straight insertion of the pedicle screw in the mid-sagittal plane provides the strongest stability.

Rotational stability can be improved by adding transverse connectors. The indications for their use include anterior column instability, and the correction of rotational deformity.

*Scientific Material For Purpose Of Education Has Been Gathered From The Journal of Bone & Joint Surgery (Br) 2010, 92-B: 1061-5 – ANNOTATION- The Biomechanics of pedicle screw-based instrumentation – W. Cho, S.K. Cho, C. Wu*

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**Chief Editor**
**Prof. P. S. Ramani**

## Salient Features

- Profusely illustrated and multicolored.
- Master techniques of pedicle screw insertion at all spinal levels.
- Screw entry points described precisely at all spinal levels
- Contributions from leading spinal surgeons in India and abroad.
- Useful knowledge and experience for young spinal surgeons of the editor-in-chief Dr. P S Ramani

## About Author

PS Ramani is a Senior Consultant Neuro-spinal surgeon at Lilavati Hospital and Research Centre, Mumbai, Maharashtra, India. He has retired as Professor and Head, Department of Neuro and Spinal Surgery, Lokmanya Tilak Municipal (LTM) Medical College and Hospital University of Mumbai. He is Founder and Past President Neuro Spinal Surgeons' Association of India; Past Chairman, World Federation of Neurosurgical Societies - Spine Committee; Past Editor-in-Chief, Indian Edition of American Journal - Spine, and Founder and Past Editor-in-Chief, Journal of Spinal Surgery. For the past 45 years, he has dedicated to the development of Spinal Surgery in India and is the Pioneer Spinal Surgeon of India. Amongst his various pioneering efforts, setting up an up-to-date Neurosurgery Department at the LTM Hospital in Mumbai, and the first Bone Bank in the country are his milestone contributions. He has several breakthroughs in surgical techniques which have helped to minimize the perception of pain and suffering till then associated with neurosurgery. Since 1985, he has mastered and popularized techniques such as Posterior Lumbar Interbody Fusion (PLIF), Internal Decompression for Spinal Stenosis (IDSS), Anterior Cervical Fusion, Transoral Surgery, Microlumbar Discectomy, Anterior Approaches to Cervical and Thoracic Spine, Cervical Corpectomy, and Laminoplasty by devising his own methodology, Cervical Discoplasty, Dynamic Stabilization and facet stabilization. He has invented several implants in spinal surgery such as Dowel and Horseshoe Type ACF Implants, Dynamic Corpectomy Cages and Artificial Cervical Disc. He has published several textbooks in spinal surgery including Textbook of Spinal Surgery (2 vols.), Textbook of Cervical Spondylosis, Backache and Sciatica, Posterior Lumbar Interbody Fusion, Atlas of Cervical Spine, Modern Trends in Neurotrauma, History of Spinal Surgery, Lumbar Fusion and Stabilization, Textbook on Surgical Management of Cervical Disc Herniation, WFNS Textbooks on Cervical, Thoracic and Lumbar spine (3 separate volumes), etc. He has also published several monograms on techniques in spinal surgery and has published 18 CDs on various techniques in spinal surgery which are widely in circulation and available on YouTube. His books for common man such as Standing Tall (his autobiography), Stop Worrying about Backache, Doctors and Patients, Common Surgeries, Pain in Your Neck, Knowledge of Brain, etc. are read with extreme interest and received accolades and appreciations. Besides conducting activities at all India and international levels, he holds annual workshops of live operative demonstrations and Hands on Cadavers Workshops all over the world. He has established School for Training Neuro and Orthopedic Surgeons in Spinal Surgery and has trained more than 4,000 surgeons in spinal surgery. His birthday on 30th November is celebrated as Neuro-spinal Day all over India and many other countries. At the age of 81 years, his zeal, enthusiasm and activities are the same and have ventured to publish one more book on the techniques of pedicle screw fixation at various spinal levels.

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