Percutaneous Lumbar Fixation Utilizing Pedicle Screws Versus Open Techniques: A Systematic Review

A Study Submitted for Partial Fulfillment of Masters Degree in Neurosurgery.

By
Ahmed Mahrous Ibrahim Rehan
M.B.B. Ch, Faculty of Medicine, Ain Shams University

Under Supervision of
Prof. Dr. Emad Mohamed Ghanem
Professor of Neurosurgery
Faculty of Medicine - Ain Shams University

Prof. Dr. Ahmed Faisal Toubar
Assistant Professor of Neurosurgery
Faculty of Medicine - Ain Shams University

Prof. Dr. Salah Mostafa Hamada
Assistant Professor of Neurosurgery
Faculty of Medicine - Ain Shams University

Faculty of Medicine
Ain Shams University
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List of Abbreviations

Abb.	Full term
ALL	*Anterior Longitudinal Ligament*
AP	*Antero-Posterior*
ECM	*Extra Cellular Matrix*
GAGs	*Glycosaminoglycans*
IAP	*Inferior Anteroposterior*
ITL	*Inter-Transverse "Ligament"*
LF	*Ligamentum Flavum*
MRI	*Magnetic Resonance imaging*
ODI	*Oswestry Disability Index*
PA	*Posterior to Anterior*
PLL	*Posterior Longitudinal Ligament*
RTAs	*Road Traffic Accidents*
SAP	*Superior Anteroposterior Dimension*
SCI	*Spinal Cord Injury*
TFLs	*Transforaminal Ligaments*
VAS	*Visual Analogue Scale*

ABSTRACT

Background: Percutaneous Pedicle screw fixation was introduced in 2002. It enables similar therapeutic efficacy to open techniques while having the advantage of minimal approach-related trauma and muscle stripping which translates to better clinical outcomes. This requires better imaging techniques and steeper learning curves compared to the open approach to lumbar pedicle screws.

The aim of this study was to compare the therapeutic efficacy and clinical outcomes of the percutaneous approach to the open pedicle screw fixation approach.

Methodology: This study is a systematic review of current literature comparing open and percutaneous approaches to the lumbar spine pedicle screw fixation. 20 studies were included.

Results: Those who underwent the percutaneous lumbar pedicle screw fixation approach had shorter operation times, less bleeding intra- and post-operatively, lower Visual Analogue Scale (VAS) scores, lower Oswestry Disability Index (ODI) scores and shorter hospital stay compared to those who underwent the open approach.

Conclusion: Both open and percutaneous approaches to lumbar pedicle screws have equal efficacy in placing the screws. The percutaneous approach can achieve these results with less approach-related morbidity and complications but has a steep learning curve and heavily depends on imaging.

Keywords: Lumbar fixation, Pedicle screws, Percutaneous, Open.

Introduction

The first posterior lumbar fusion was introduced by Cloward in 1953 for degenerative disc disease and spondylolisthesis.[1] Since then, pedicle screw instrumentation has enabled a rigid construct to promote stability and fusion for numerous spinal pathologies including: trauma, tumors, deformity and degenerative diseases.[2,3]

Traditional open spine surgery for pedicle screw placement has been the norm during the past few decades when it comes to posterior lumbar fusion, yielding successful outcomes in approximately 80% of patients with fusion rates near 90%.[4,5]

The safety of this technique has been well established; however, it has several reported limitations including extensive blood loss, infection risk and post-operative muscle pain. The para-spinal muscle dissection involved in open spine surgery can cause muscular denervation, increased intramuscular pressure, ischemia, necrosis and revascularization injury resulting in muscle atrophy and scarring, often associated with prolonged post-operative pain and delayed resumption of activity. [3,-6]

Percutaneous spinal fixation utilizing muscle-dilating approaches to minimize surgical incision length, surgical cavity size and the amount of iatrogenic soft-tissue injury associated with surgical spinal exposure, without compromising outcomes, is thus a desirable advancement.[3-6]

Due to the advantages of minimally invasive surgery (MIS), demand for percutaneous pedicle screw insertion has been increasing. In 1995, Matthews and Long introduced the first percutaneous lumbar instrumentation using pedicle screws connected by subcutaneous plates placed above the dorso-lumbar fascia.[7] In 2000, Lowery et al. subsequently described a similar procedure utilizing a rod as the joining member.[8] In 2002, Foley introduced the Sextant system for the purpose of achieving a percutaneous pedicle screw rod fixation.[4,5]

Since 2002, several other percutaneous fixation systems have been introduced and the techniques of minimally invasive spinal fusion have improved substantially.[9] With increasing experience, indications for minimally invasive spinal fusion have expanded. Currently, indications are similar to those for open surgery and strongly rely on the surgeon's experience with the procedure.[10]

However, percutaneous lumbar pedicle screw fixation may prove superior to conventional open technique in some indications such as: mechanical lower back-pain, grade I and II spondylolisthesis-associated radicular pain, recurrent disc herniation, low back pain resulting from post laminectomy instability and obese patients where all spinal surgeries prove more difficult and have higher morbidity rates.[3-11]

AIM OF THE WORK

To review and analyze therapeutic efficacy of percutaneous pedicle screw fixation of lumbar spine versus open techniques in patients with lumbar degeneration and instability and/ or lumbar fractures.

ANATOMY OF THE LUMBAR SPINE

Osseous structures

There are five lumbar vertebrae, followed by the sacrum making up the lumbosacral spine. Each lumbar vertebra has 2 parts, the vertebral body and neural arch. The vertebral body; lies anteriorly, and its dimensions gradually increase from cephalad to caudal, and it is designed to bear weight. When viewed from above, the superior surface of vertebral body is wider transversely and is kidney shape. The discal surface of an adult vertebral body demonstrates on its periphery a ring of cortical bone. This ring, the epiphyseal ring, acts as a growth zone in the young and in the adult as an anchoring ring for annular fibers. The hyaline cartilage plate lies within the confines of this ring. The neural arch; lies posterior to the vertebral body and consists of a pair of pedicles emerging from the posterolateral surface of the upper portion of vertebral body. These join with paired laminae, which are located further posteriorly, and are designed to protect the neural elements.[12]

The portion of the lamina between the superior and inferior articular processes and just below the level of the pedicle is the isthmus or pars interarticularis. This is a common site for stress fractures. From the junction of two laminae, a spinous process arises posteriorly. It is almost horizontal, quadrangular, and thickened along its posterior and inferior borders.[13]

Articulations

The articulations include the intervertebral disc anteriorly and a pair of facet or zygapophyseal joints posteriorly, reinforced by muscles and ligaments.

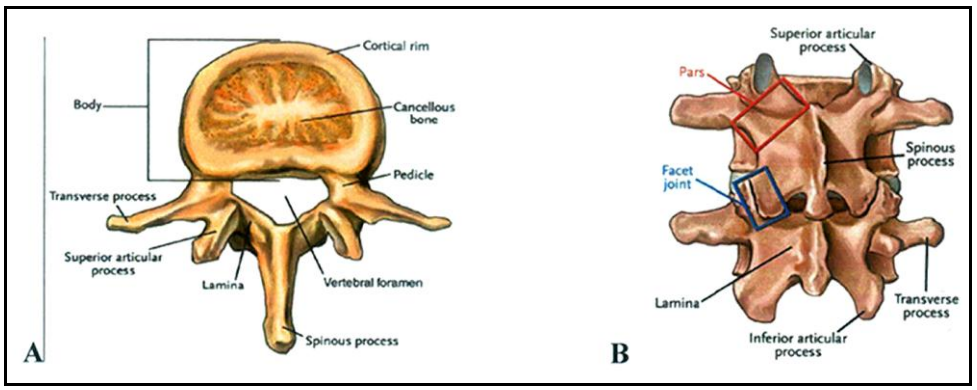

Figure (1): Osseous structures of the lumbar spine, A; Lumbar Vertebra. B; Posterior view of the lumbar spine.[14]

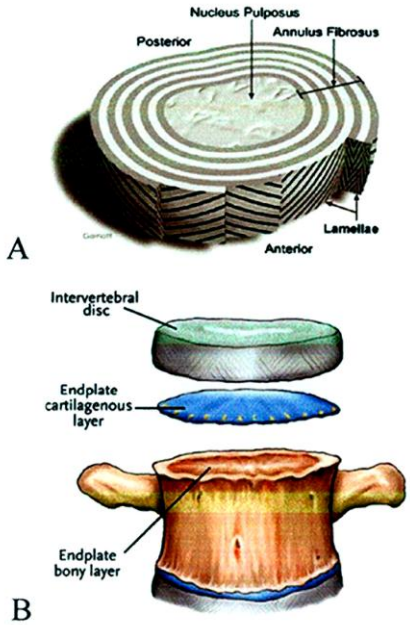

Figure (2): (A and B): The intervertebral disc. [14]

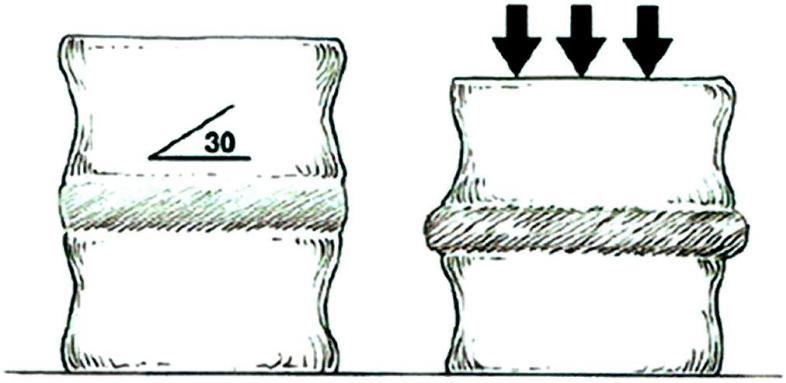

Figure (3): The annulus fibrosus is composed of layers of collagen fibers. The collagen fibers are oriented at 30° relative to the endplate. The orientation alternates with each successive layer. (16)

The intervertebral disc

Function: intervertebral discs stabilize the spine and maintain its alignment by anchoring adjacent vertebral bodies to each other. They also allow flexion, extension, and lateral bending motions between vertebrae that give the spine its flexibility, and they absorb energy and distribute loads applied to the spine.(15)

Structure: the disc tissue is best described as a specialized form of fibro-cartilage. The intervertebral disc is composed of three elements; the central portion of the disc contains the nucleus pulposus, surrounded by the annulus fibrosus, and the cartilaginous end plates adjacent to the surfaces of the vertebral bodies.(16)

1) **The Annulus;** it forms the circumferential rim of the disc. The annulus has a multilayer lamellar architecture made of collagen fibers. Within each layer, the collagen