Role of Including the Index level in Short Segment Pedicular Fixation in Traumatic Thoraco-Lumbar Fractures

A Systematic Review

Submitted for Partial Fulfillment of
Master Degree in **Neurosurgery**

By

Ahmed Adel Nabih
M.B.B.Ch; Faculty of Medicine, Ain Shams University

Under Supervision of

Prof. Dr. Ayman Abd-El-Ra'ouf EL-Shazly
Professor of Neurosurgery
Faculty of Medicine, Ain Shams University

Prof. Dr. Salah Mostafa Hamada
Associate Professor of Neurosurgery
Faculty of Medicine, Ain Shams University

Dr. Ahmed Maged Nagaty
Lecturer of Neurosurgery
Faculty of Medicine, Ain Shams University

Faculty of Medicine - Ain Shams University
2020

Abstract

Background: It is generally acknowledged that short-segment pedicle screw instrumentation is the preferred surgical method for thoracolumbar fractures. However, the use of short-segment instrumentation with or without intermediate screws at the fracture level remains controversial. This review will evaluate the evidence available to date regarding the efficacy of including the fracture level in trans-pedicular screw short segment fixation, to assess clinical and radiological outcome.

Objectives: Our primary objective is evaluating the efficacy and outcome of including the fractured level vertebra in short segment fixation. And concerns regarding the use of pedicle screws into the fractured vertebra as to whether it is safe to insert a screw through a broken bone. Our secondary objective analyzing the importance of posterior pedicle screw fixation in unstable thoracolumbar fractures.

Methods: The following electronic databases will be searched from 1992 to 2018: PubMed, Google scholar search engine. Cochrane database of systematic reviews, EMBASE and science Direct, using the keywords “TLICS”, "index screw", “short segment fixation”, "Thoracolumbar spine trauma", "traumatic spine injury", "spinal cord injury", "spine trauma", "role", “reliability”.Studies will be eligible if they contain the target keywords in title or abstract, addressing our age group. Afterwards the full text of the articles will be reviewed to exclude full texts not fulfilling the criteria or deviating from the initial impression taken from the title/abstract reviewing. References/bibliography of the selected articles will be examined to evaluate potential for further research and possible inclusion in the analysis. Any differences will be sorted by discussion between study team (student, director, and co-directors).

Results: A total of 3010 studies were screened for eligibility , 8 studies were included in our systematic review for comparing the short segment fixation “including” the fracture level with “conventional” methods whether short or long segment fixation. Overall study population reached 512 patients. Analysis showed comparable results regarding clinical picture and radiography, showing highly statistically significant difference in favor of “including” index level in fixation in post operative kyphosis angle correction, loss of correction of kyphosis angle through follow up until 2 years and loss of correction of AVH, also statistically significant difference in rate of implant failure in favor for “including” group, and with no significant difference in operative time , blood loss and VAS for post-operative pain.

Conclusion: We conclude that Short segment fixation including the fracture level is a promising surgical option when it comes to thoraco-lumbar unstable fractures. In conclusion, inclusion of the fracture level into the construct offers a better kyphosis correction, in addition to fewer instrument failures, without additional complications, and with a comparable-if not better-clinical outcome, the radiologic correction achieved is maintained even at the end of 2 years and reflected in good functional outcomes. We recommend insertion of screws into pedicles of the fractured thoracolumbar vertebra when considering a short segment posterior fixation, especially in Magerl type C fractures. Large population prospective randomized controlled studies and clinical trials are recommended for more high level evidence data.

Keywords: Short Segment Pedicular Fixation, Traumatic Thoraco-Lumbar Fractures

Introduction

It is generally acknowledged that short-segment pedicle screw instrumentation is the preferred surgical method for thoracolumbar fractures. However, the use of short-segment instrumentation with or without intermediate screws at the fracture level remains controversial.[1]

Around 60% to 70% of traumatic spinal fractures are related to thoracolumbar (TL) region which ranges from T11 to L2. Acute fracture of the thoracolumbar spine is a major cause of disability in adult population. Posterior transpedicular fixation has been the preferred method for stabilizing acute unstable thoracolumbar fractures.[2]

Short segment fixation of the fracture level has replaced the traditional long segment instrumentation to decrease the number of motion segments sacrificed in the fusion process.[2]

However, when there is significant disruption of the load-sharing anterior column, the simple one level above and one level below short segment fixation does not ensure adequate stability, resulting in poor reduction in the kyphotic deformity and occurrence of instrument failure.[3]

Most authors reported that intraoperative correction of sagittal deformity is important for the maintenance of fracture reduction and is one of the most consistent predictor of satisfactory functional outcome.[4]

During the past 3 decades, its treatment has undergone immense advances. For unstable thoracolumbar fractures, surgical intervention is preferred.The goals of treatment for unstable thoracolumbar vertebral fracture include repairing vertebral column stability, preventing or reducing deformity, spinal canal decompression, and early mobilization.[5] Among all operative strategies, posterior short-segment pedicle instrumentation is most widely used for thoracolumbar fractures worldwide because of its 3-column fixation.[3] In addition, its ease of application, use of fewer surgical fixation materials, reduction of blood loss, and smaller incision field also make it more popular in clinical practice.

In most burst fractures, the posterior column at the level of the fracture remains intact and provides additional points of fixation. Insertion of pedicle screws at the level of the fracture would result in a segmental construct that may improve biomechanical stability. Also, this supplemental screw may have a protective effect on the fractured vertebral body by indirectly supporting the anterior column.[5] However the use of short segment fixation with intermediate level screw remains one of many controversies in the vast world of spinal neurosurgery.

This review will evaluate the evidence available to date regarding the efficacy of including the fracture level in trans-pedicular screw short segment fixation, to assess clinical and radiological outcome.

AIM OF THE WORK

Comparing short segment fixation including the fracture level to long segment fixation in thoraco-lumbar fractures regarding outcome and system failure and analysing the importance of fixation for unstable traumatic fractures

Objectives:

Primary objective:

Evaluating the efficacy and outcome of including the fractured level vertebra in short segment fixation. And concerns regarding the use of pedicle screws into the fractured vertebra as to whether it is safe to insert a screw through a broken bone.

Secondary objectives:

Analyzing the importance of posterior pedicle screw fixation in unstable thoracolumbar fractures,

REVIEW OF LITERATURE

Embryology of the Thoracolumbar Spine

Segmentation of Para-axial Mesenchyme

Epiblast cells which ingress through the primitive node and the primitive streak become committed to a somitic lineage. The cells form populations of paraxial mesenchyme on each side of the notochord, termed presomitic or unsegmented mesenchyme. Somites will form from cultured presomitic mesenchyme[6].

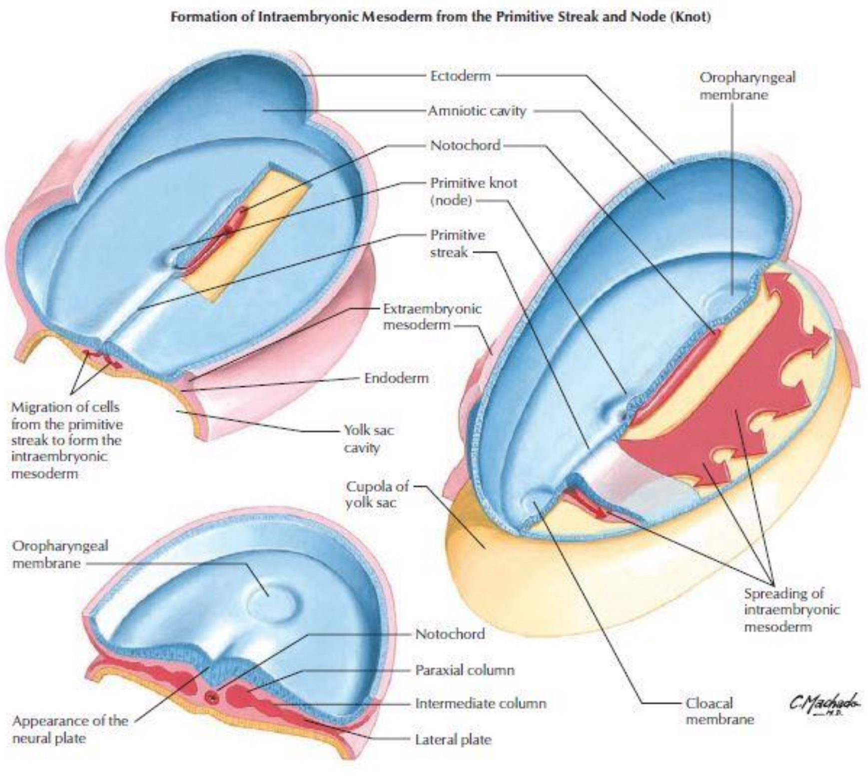

Fig. (1): Formation of intraembryonic mesoderm from the primitive streak and primitive node[7].

Somitogenesis

After the onset of neurulation (embryo folding), the paraxial mesenchyme undergoes segmentation in a craniocaudal progression and forms discrete clusters of mesenchyme cells called Somites.

The cells within the somite undergo somitogenesis, a process-in which five main stages can be identified. These are (1)compaction, (2)formation of spherical epithelial covering and a core of free somitocoele cells, (3)epithelial/mesenchymal transition of ventromedial walls of the somite to form the sclerotome, (4)bilateral migration of the ventromedial mesenchyme towards the notochord to form the perinotochordal sheath, and (5)while the remaining unmigrated epithelium forms the dermomyotome[8].

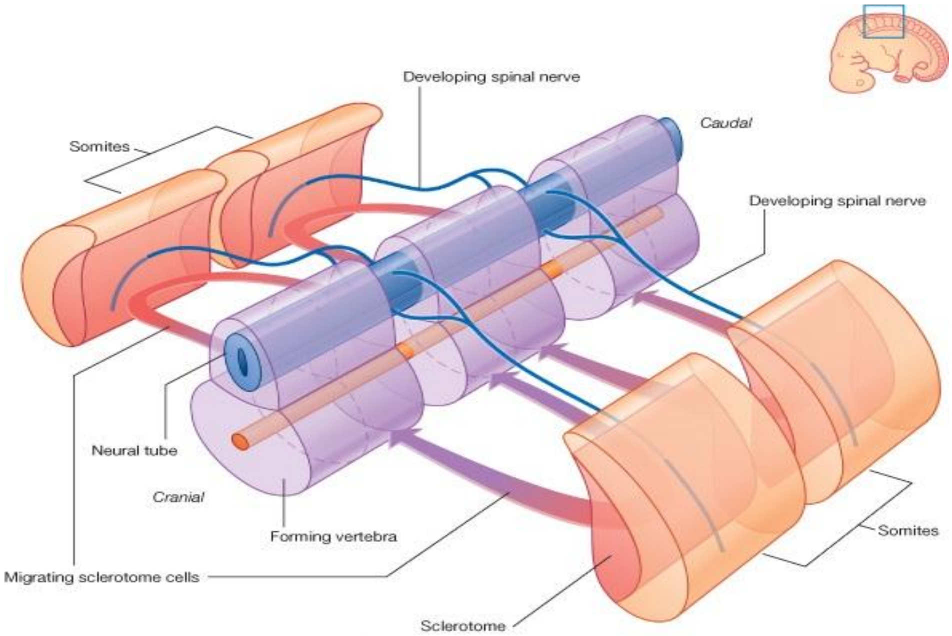

Fig. (2): Somitogensis and development of Sclerotomes[9].

Development of Sclerotomes

The bilateral sclerotomal cell populations migrate towards the notochord and surround it to form the perinotochordal sheath. An intrasegmental boundary (fissure or cleft, sometimes termed von Ebner's fissure) appears within the sclerotome, dividing it into loosely packed cranial and densely packed caudal halves (Fig 2). Their fusion around the notochord produces the blastemal centrum of the vertebra[10].

The blastemal centrum encloses the notochord and lies ventral to the neural tube. The neural processes extend from the dorsolateral angles of the centrum and curve to enclose the neural tube and form the neural arch. On each side three further processes project cranially, caudally and laterally from a point that will be the future junction of the pedicle and laminae. The cranial and caudal projections are the future articular processes (zygapophyses) and facets. The lateral projections are the true vertebral transverse processes. Bilateral costal processes (ribs) grow anterolaterally at most thoracic levels. The costal processes expand to meet the tips of the transverse processes. The definitive vertebral body is compound with bilateral neurocentral synchondroses (Fig 3)[8].

Intervertebral discs

An intervertebral disc is formed from the free somitocoele cells within the somite and segmental expansion of the notochord between vertebrae which form the nucleus pulposus of the future intervertebral disc. After the sixth month of fetal life, notochordal cells in the nucleus pulposus degenerate, and are replaced by cells from the internal zone of the anulus fibrosus. This degeneration continues until the second decade of life, by which time all the notochordal cells have disappeared[8].

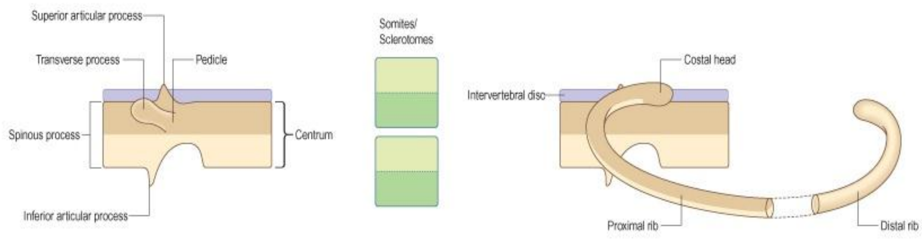

Fig. (3): Development of vertebrae and inter vertebral discs[8].

Development of vertebrae

Chondrification of the blastemal centrum begins initiating the cartilaginous stage. Each centrum chondrifies from one cartilage anlage, while each half of the neural arch is chondrified from a centre. The transverse and articular processes are chondrified in continuity with the neural arches. Intervening zones of mesenchyme which do not become cartilage mark the sites of the facet joints and the complex of costovertebral joints, within which synovial cavities later appear[10].

Similarly, a typical vertebra is ossified from three primary centres, one in each half vertebral arch and one in the centrum. Centres in arches appear at the roots of the transverse processes, and ossification spreads backwards into laminae and spines, forwards into pedicles and posterolateral parts of the body, laterally into transverse processes and upwards and downwards into articular processes[8].

At birth and during early postnatal years the centrum is connected to each half neural arch by a synchondrosis or neurocentral joint. In thoracic vertebrae costal facets on the bodies are posterior to neurocentral joints (Fig 4&5)[8].

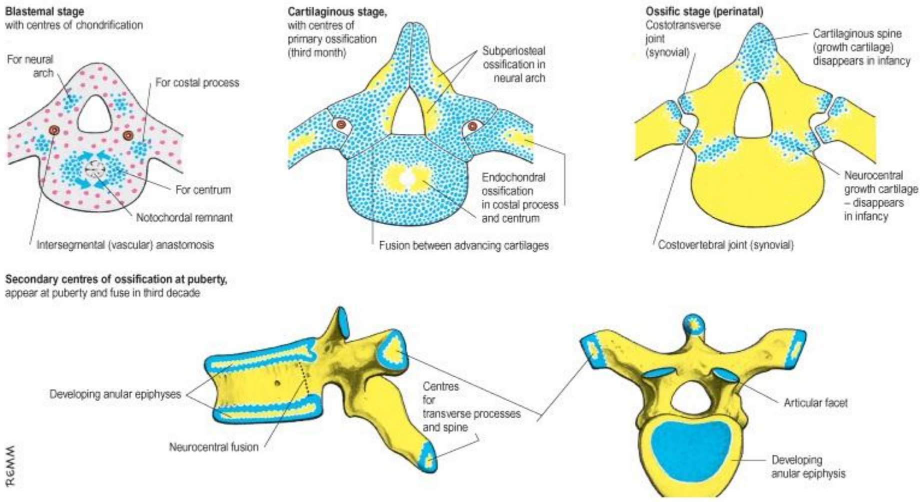

Fig. (4): Chondrification and Ossification patterns of vertebrae[8].

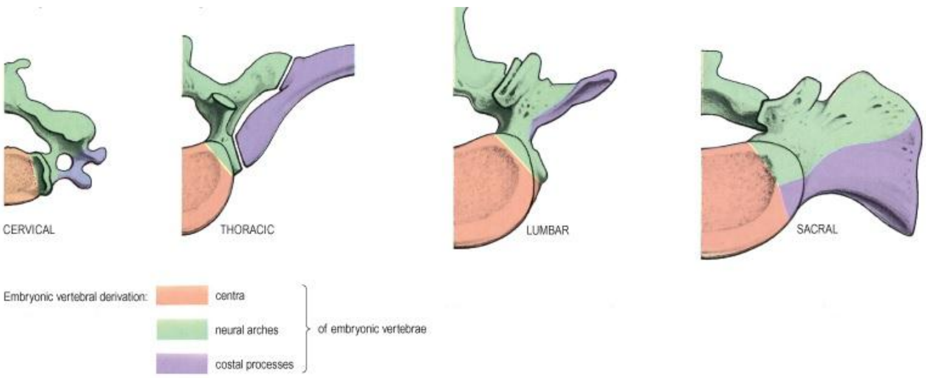

Fig. (5): Derivatives of embryonic vertebrae in adult spine[8].

Anatomy of the Thoracolumbar Spine

Vertebrae

A typical vertebra has a ventral body, a dorsal vertebral (neural) arch, extended by lever-like processes (2 transverse, spinous, superior articular and inferior articular processes) and a vertebral foramen, which is occupied by the spinal cord, meninges and their vessels ,(Figure 6,7)[9].

Fibrocartilaginous Intervertebral discs bind opposed surfaces of adjacent bodies together. The complete column of bodies and discs forms the strong but flexible central axis of the body and supports the full weight of the head and trunk. It also transmits even greater forces generated by muscles attached to it directly or indirectly. The vertebral foramina form a vertebral canal for the spinal cord, and between adjoining neural arches, near their junctions with vertebral bodies, intervertebral foramina transmit mixed spinal nerves, smaller recurrent nerves and blood and lymphatic vessels[11].

Pedicles are dorsal projections from the superior part of the body at the junction of its lateral and dorsal surfaces. The concavity formed by the superior border of the pedicle is shallower than the inferior one[8].

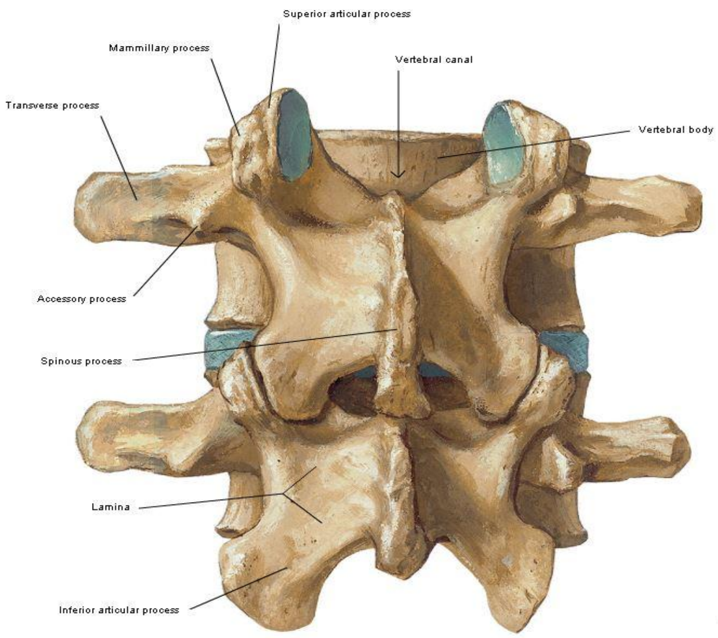

Fig. (6): General features of vertebrae (Posterior view)[12].

The laminae are directly continuous with the pedicles and with the base of the spinous process completing the vertebral foramen. The spinous process (vertebral spine) projects dorsally and often caudally from the junction of the laminae. The spines act as levers for muscles that control posture and active movements of the vertebral column. The paired superior and inferior articular processes (zygapophyses) arise from the vertebral arch at the pediculolaminar junctions. The superior processes project cranially (bearing dorsal facets) and Inferior processes run caudally (with ventral articular facets); both meeting to form the facet joints. These joints permit limited movement between vertebrae. Transverse processes project laterally from the pediculolaminar junctions as levers for muscles and ligaments[9].

The thoracic transverse processes articulate with ribs, but at other levels, the mature transverse process is a composite of 'true' transverse process and an incorporated costal element (Fig 7). Lateral to the spinous processes, vertebral grooves contain the deep dorsal muscles. At lumbar levels, these grooves are shallow and mainly formed by laminae. In the thoracic region, they are deeper, broader and formed by the laminae and transverse processes[8].

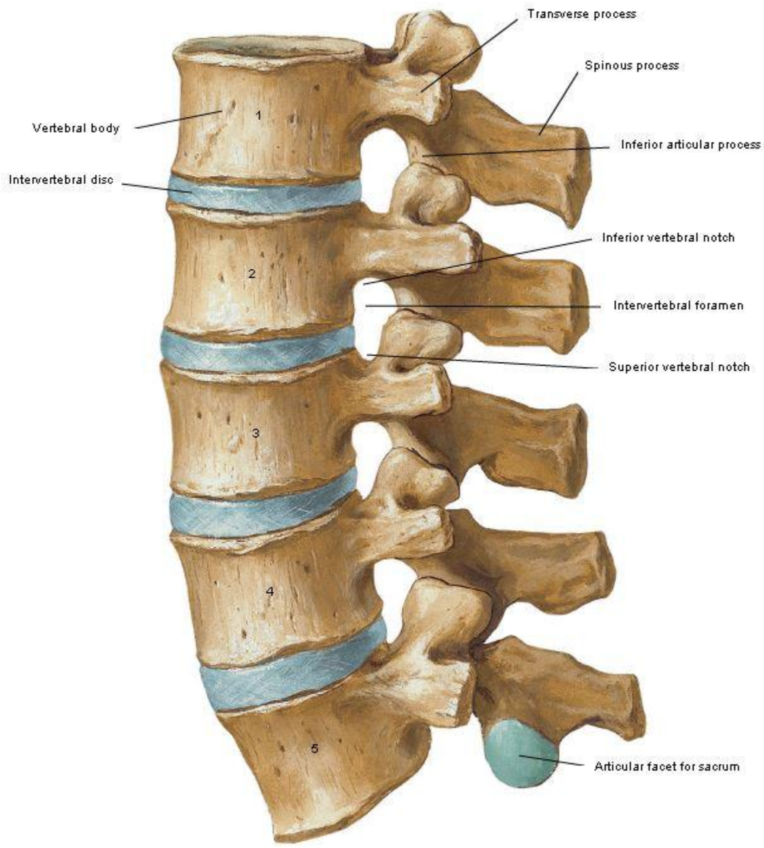

Fig. (7): General features of vertebrae (lateral view)[12].

Vertebral Canal

The vertebral canal extends from the foramen magnum to the sacral hiatus, and follows the vertebral curves. In the cervical and lumbar regions, which exhibit free mobility, it is large and triangular, but in the thoracic region, where movement is less, it is small and circular. These differences are matched by variations in the diameter of the spinal cord and its enlargements[8].

Intervertebral Foramina

The intervertebral foramen is bounded anteriorly by the posterolateral aspect of the vertebral bodies and intervening discs. Superiorly and inferiorly by the pedicles. Posteriorly it is bound by the facet synovial joint with its fibrous capsule. In addition, the anteroinferior boundaries of the first to tenth thoracic foramina are formed by the articulations of the head of a rib with the demifacets on adjacent vertebrae. Lumbar foramina lie between the two principal lines of vertebral attachment of psoas major. The radicular or 'root' canal contains a segmental mixed spinal nerve and its sheaths, two to four recurrent meningeal (sinuvertebral) nerves, variable numbers of spinal arteries, and plexiform venous connections between the internal and external vertebral venous plexuses[11].