Surgical Modalities Preserving Lumbar Spinal Motion

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Abstract

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Spinal fusion is the gold standard treatment of patients with disabling low back pain due to degenerative disc disease not responding to conservative therapy. Fusion procedures have been linked to a variety of negative side effects such as adjacent segment degeneration and instability, superior segment facet joint violation, adjacent segment spondylarthrosis with consecutive spinal canal stenosis as well as persisting pain from harvesting of the autologous bone graft. Previous studies have revealed the facet and iliosacral joints to be a source of post-operative pain in a considerable number of patients. Alterations of the segmental, sagittal and spinopelvic alignment as well as increased motion and stress adjacent to fused levels have been held responsible for post-fusion pain patterns. In an attempt to avoid fusion-related negative side effects.

Lumbar disc replacement procedures have become increasingly popular and various clinical trials have shown satisfactory results following TDR. One of the primary aims of TDR is to preserve motion and thereby ultimately avoid stress and degeneration of the adjacent segment. Radiographic studies have demonstrated maintained physiological sagittal and spinopelvic alignment following TDR. It has therefore been hypothesized that the above-mentioned fusion-related negative side effects and post-fusion pain patterns could be avoided with TDR.

While representing a breakthrough in the treatment of many patients with ongoing back pain, disc replacement cannot be expected to address pain in all patients with low back pain, as the source of the patient's pain is not always a painful disc or well defined. For example, total disc replacement does not address pain originating from the posterior elements such as pain that originates from the facet joints, ligaments, tendons or muscles. Posterior conditions, such as spinal stenosis, may be improved with posterior motion preservation devices.

This new category of thoracolumbar spinal surgery focuses on the concept of maintaining or restoring intervertebral motion in a controlled fashion, whether by restricting the extremes of spinal movement or by dampening the kinetic energy involved in motion. The goal of these surgeries is to mimic the behavior of the healthy spinal column.

These devices can be put into three general categories:

Interspinous Spacer Devices

By keeping the spine in a rather flexed position, the interspinous devices increase the total canal and foraminal size, decompressing the quada equina

Pedicle Screw/Rod-Based Stabilization Devices

By unloading the pressure on the degenerated discs and facets, pedicle-based dynamic devices have the potential to reduce pain associated with these anatomical structures.

Total Facet Replacement Systems

Total facet replacement is an emerging new technology designed to completely restore facet joints functionally.

Most of these Devices are under trial and several controlled prospective studies are ongoing to assess the effectiveness of these devices.

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Introduction

Spinal fusion was the standard surgical care for numerous pathologic conditions of the spine. Spinal fusion surgery is frequently performed to treat spinal disorders such as spondylolesthesis, scoliosis, degenerative disc disease (DDD), and instability of the spine or spinal fractures.

The concept of motion preservation in the spine is an essential one and the methods of non-fusion technologies being introduced to the field of practice offer a great deal of promise for spinal surgery patients.

However, despite the fact that some of these technologies have been in use for many years, the clinical outcome data available are extremely limited in proportion to the numerous procedures performed. While this hasn't apparently inhibited international growth, regulatory clearance criteria in the U.S.A. are by far the most difficult in the world. As such, the paucity of well-designed studies to prove the safety and effectiveness of artificial discs may hinder growth in the U.S.A.

What has become clear is that for optimal results, patient selection is critical with poor selection too often resulting in poor outcome. For certain segments of the patient population, traditional fusion will remain the appropriate therapy.

An alternative to spinal fusion in the treatment of DDD is an artificial intervertebral disc. Unlike spinal fusion which achieves pain relief through immobilization, artificial discs maintain motion at the operative level once the damaged disc has been removed. By preserving normal physiological motion, it is thought this may also reduce or prevent the development of adjacent segment degeneration.

Other motion preserving techniques such as minimally invasive discectomy, interspinous spacers, interspinous bands, laminoplasty, pedicle-based dynamic rod devices and other methods will be discussed in details in this study.

In addition, in motion preserving surgical procedures a bone graft is not required and this alleviates complications and morbidity associated with bone grafting such as bone graft donor site pain and pseudo-arthrosis.

Motion preserving techniques can offer great solution for so many diseases of the spine such as spondylolisthesis, degenerative disc disease (DDD), and instability of the spine or spinal fractures.

However, there are some obstacles against spreading of these techniques such as costs of implants, availability of implants, availability of trained staff that can perform such procedures and other problems that we'll discuss in this study.

Chapter 1

Physiology and pathomechanics of spinal motion

Anatomical considerations:

There are five lumbar vertebrae and the sacrum making up the lumbosacral spine. We can consider each vertebra as having three functional components: the vertebral body, designed to bear weight; the neural arches, designed to protect the neural elements; and the bony processes (spinous and transverse), designed to increase the efficiency of muscle action. The vertebral bodies are connected by the intervertebral discs, and the neural arches are joined by the facet (zygapophyseal) joints. The discal surface of an adult vertebral body demonstrates on its periphery a ring of cortical bone. This ring, the epiphysial ring, acts as a growth zone in the young and in the adult as an anchoring ring for the attachment of the fibers of the annulus. The hyaline cartilage plate lies within the confines of this ring. (1)

The neural arch is composed of two pedicles and two laminae.The pedicles are anchored to the cephalad half of the vertebral body and together with the laminae form a protective cover for the cauda equina contents of the lumbar spinal canal. The ligamentum flavum fills in the interlaminar space at each level. Vertebrae, discs and ligaments form a column of vertebral motion segments, called functional spinal units. Each functional spinal unit includes a disc, the two adjacent vertebrae and the connecting ligaments (Fig 1.1). Due to the presence of discs and ligaments, the whole spine acts as a flexible column straight in the frontal plane and curved in the sagittal plane. The curved alignment of the spine in the sagittal plane increases spinal flexibility and the ability to withstand mechanical forces, whilst maintaining the stability of the spine. (1)

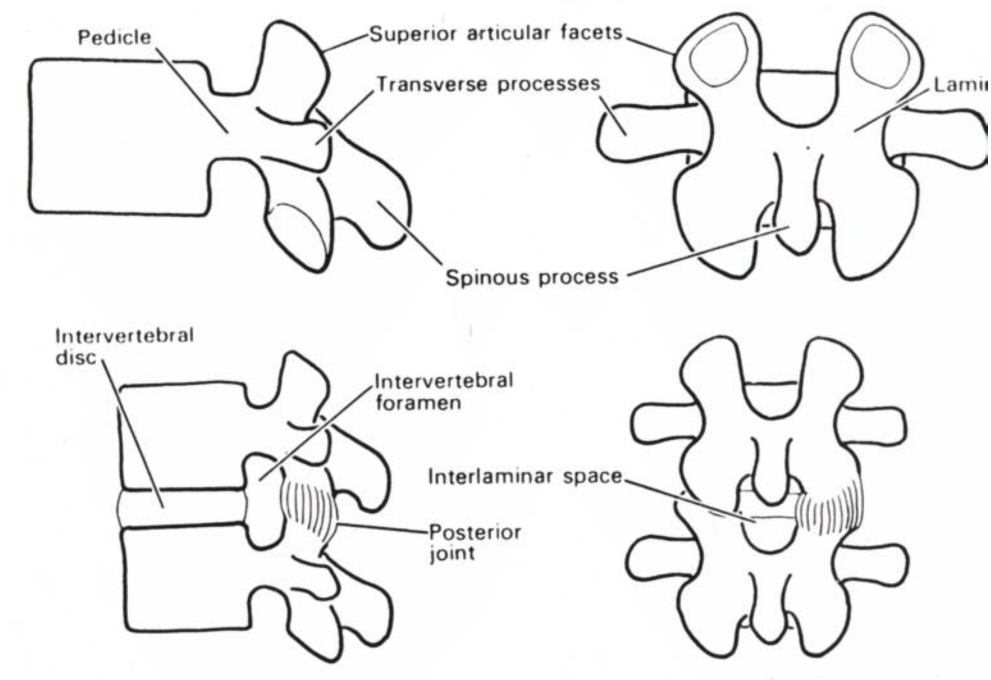

Fig. 1.1: The components of functional spinal unit [1]

The Intervertebral Disc (function and structure):

Physiological function of the axial skeleton is made possible by the intervertebral discs. They approximately 7–10mm thick and 4 cm in diameter (anterior–posterior plane) in the lumbar region of the spine. They stabilize the spine and maintain its alignment by anchoring