Lumbar Spine Fusion

*Anatomical Considerations***:** The lumbar facet joints have a sagittal plane orientation that favors flexion/extension motions at the expense of axial rotation. A large flexion torque delivered to the thorax may concentrate an excessive hyperflexion stress at the extreme upper lumber region. Orientation of the lumbosacral junction facets and sacrohorizontal angle increases a shearing effect. Hyper-mobility in the lumbar segments occurs due to thoracic spine rigidity and sacral/pelvis stability. The increased motion is disbursed only across the five intervertebral junctions. Due to increased motion, the lumbar discs can degenerate, which can lead to disc herniations, nerve root impingements, and vertebral instability. A leading cause of disc degeneration and instability may be from poor postural control.

*Pathogenesis***:** Lumbar vertebrae and/or discs can be structurally compromised by many different factors. Instability can come from trauma directly to the spinal vertebrae/discs or peripherally that may affect the pull on the vertebras. Infections or tumors of the vertebral column can greatly affect alignment. Inherited or idiopathic scoliosis causes a cascade of muscle imbalance and structural changes. Spondylolisthesis occurs from anatomical mal-alignment and/or inadequate postural control. These listed conditions tend to be the primary pathologies indicating a spinal fusion. Conditions still under debate for indications are age related physiological changes such as disc dehydration which can contribute to disc degeneration and/or herniation, and conditions such as spondylolysis, or spondylosis.

Epidemiology: Degeneration of the spine sometimes has a hard delineation of cause. It can be inherited or acquired. The largest contributing factor to both origins is poor postural control and improper biomechanical loading. Lumbar disc herniations or internal disc disruption, are one of the most frequent herniation sites in the spine, with approximately (85%) occurring at the L4-L5 level. Disc herniations usually are the result of two different mechanisms. One, from a large, sudden compression force delivered over the lumbar spine that is flexed or flexed and axially rotated, and is usually associated with a single event. The second resulting from a series of multiple, low magnitude compression forces, often imposed over a flexed lumbar spine and usually occurs gradually from cumulative microtrauma (poor posture with loading). If a disc disruption leads to significant instability, surgical fusion may be attempted (Note: Not all surgeons agree that internal disc disruptions are an indication for spinal fusion).
Another source of degeneration is primary OA, which cause is unknown, however, it is termed as the wear and tear arthritis. Articular cartilage breaks down because of an imbalance between the mechanical stresses and the ability of the joint structures to handle the loads put upon them. Once the cartilage begins to breakdown, a cascade of tissue failure follows contributing to spinal instability. Spondylolysis can occur from stress fractures caused by a traumatic event, from systemic dysfunction, or from surrounding structural imbalances usually affecting the zygapophysial joints. If this area of the vertebra is unable to handle the forces put upon them, compensatory movements will facilitate other sites of instability.
Spondylolysthesis can occur from the plane shearing effect caused by anatomical structure and poor postural control contributions.
Degenerative scoliosis, whether an inherent factor or idiopathically developed may be fused if a 30 degree curvature or more has occurred.

Diagnosis:

- Patients' clinical presentation may include low back pain with radiculopathy down the lower extremity, weakness of the legs or feet, numbness of the legs, feet, or toes, and/or loss of bowel and bladder control.
- MOI of a single event of bending down to lift or lower a heavy object (with or without twisting), immediately feeling pain in their low back of varying degrees of severity.
- Clinical evaluation using the single leg raise may indicate a herniated disc. As well as using dermatomal patterns and deep tendon reflexes to help identify nerve root involvement.
- With degenerative disc disease and/or stenosis, patients may complain of an insidious onset of back pain or a sudden onset, with or without radicular symptoms due to the severity of resulting impingement.
- X-ray to reveal amount of joint space narrowing, osteophyte formation/location, and healing confirmation in stress fractures.
- MRI scan to reveal location and severity of disc protrusion and/or nerve root impingement.
- A CT scan also may be used.
- An nerve conduction velocity test may be done to detect signs of nerve damage or to determine the exact nerve roots that are involved

Non-operative Versus Operative Management: Surgical fusion of the lumbar spine is typically recommended for patients who have unsuccessfully completed conservative therapy. This can include postural training, increasing flexibility, and improving strength within the trunk and lower extremities in an attempt to take mechanical stresses off the affected vertebral joints. Such therapy should be consistent for at least six weeks before considering surgery. Included in conservative therapy is the use of modalities such as the use of heat, cold, ultrasound, and electrical stimulation to reduce pain and muscle spasm. Hands-on treatments such as specialized forms of soft-tissue mobilization, spinal manipulation, and lumbar traction may be included. The primary purpose of therapy is to educate the patient on an independent program that facilitates proper body alignment/mechanics to ensure that muscle imbalance no longer contributes to structural changes.

The severity of the patient's pain and increased loss of function is the deciding factor of whether surgery for spinal fusion will take place. There is no guarantee that surgical intervention will fix the problem completely. There is always the possibility that complete immobilization of the fused vertebral levels will result in further degeneration/stenosis/disc herniation or spondylolysthesis occurring at surrounding vertebral levels. Instability at adjacent levels is likely to occur if proper biomechanics have not been adopted. There is also the risk of surgical damage or infection to the vertebral column or spinal cord that can cause much greater problems. Proper patient selection for spinal fusions is critical for two reasons. One, healing from a fusion procedure takes a long time (about 3 to 6 months, and up to 18 months), and two, the fusion forever changes the biomechanics of the back by increasing the stress placed on the other (non-fused) joints in the spine. Fusions are generally not recommended until a patient has tried 6 to12 months of adequate conservative care, such as physical therapy, medications, or steroid injections.

Even when conservative treatments have failed, physicians remain to have difficulty categorizing when a surgical fusion is indicated. Cumulative research shows that fusion for spondylolisthesis has excellent outcomes, but indication for other routine applications fall short. To help prove this point, a study done where nineteen spine surgeons reviewed 30 potential spinal fusion cases. Outcomes revealed that 66% of that caseload was broad disagreement as to the indication for fusion. The cases they agreed to fusions on where for patients with spondylolisthesis and scoliosis. Disagreeable cases where for patient with moderate multilevel radiographic abnormalities. Physicians debated over if indication for fusion be determined by severity of radiographic findings or relevant clinical findings. Most literature states indication for lumbar fusion as a treatment for back pain is an option for patients who:

Have failed to get better after extensive conservative treatment
Continue to have back pain that limits their ability to function
Have received a diagnosis that a specific disc space is the pain generator.

Host factors that have a negative impact on obtaining a fusion include:

- Smoking (nicotine)
- Obesity
- Osteoporosis
- Chronic steroid use
- Diabetes mellitus or other chronic illnesses
- Prior back surgery or attempted fusion
- Malnutrition

Of all these factors, the one that most negatively affects the fusion rate and is under the control of the patient is smoking. Nicotine has been shown to be a bone toxin and it inhibits the ability of the bone growing cells (osteoblasts), to grow bone. A fusion is basically a race between the bone growing cells and the bone eating cells (osteoclasts). Continuing to smoke after a fusion procedure, especially immediately after surgery, favors the osteoclasts and significantly undermines the fusion process. Since almost all fusion procedures for back pain are elective, it only makes sense for patients to make a concerted effort to quit smoking to give the best chance possible of allowing the bone to heal.

Surgical Procedures:

Posterior Spinal Fusion: An incision is made along the posterior aspect of the chosen lumbar region. To prepare the area to be fused, the surgeon shaves a layer or completely removes the lamina and/or the spinous process off the lumbar segments. The cut bone bleeds. The surgeon then may make a second incision at the hip where small strips of bone are removed from the top rim of the pelvis. This is used as the bone graft. The surgeon lays the bone strips over the back of the spinal column. When the bone graft contacts the bleeding area, the healing process and fusion of the bones together can occur just as it would a fractured bone. During the posterior spinal fusion, the surgeon also fixes the bones in place using a combination of metal screws, rods, and plates. This instrumentation or hardware holds the vertebrae to be fused together and prevents them from moving. The less motion there is between two bones trying to heal, the higher the chance they will successfully fuse. The use of instrumentation has increased the success rate of spinal fusions considerably.

Anterior lumbar fusion: Also known as anterior lumbar interbody fusion (ALIF). In this procedure, the surgeon approaches the spine from the front. Taking special care in moving vital organs, especially the abdominal aorta and inferior vena cava, as these vessels lie directly anterior to the lumbar vertebrae until they bifurcate at about L4. These great vessels are moved over to the left side in order to stretch the aorta as little as possible. The surgeon measures the depth and height between the two vertebrae, this can be done off the patients radiograph or the patient itself. Bone used to create the graft can be taken from the patients hip or from an allograph. The graft is measured to fit snugly in the space where the disc was taken out. The surgeon uses a traction device to spread the two vertebrae apart, and the graft is tamped into place. The goal of the procedure is to stimulate the vertebrae to grow together into one solid bone. Fusion creates a rigid and immovable column of bone in the problem section of the spine in attempt to reduce the patients back pain and other symptoms.

Combined fusion: Most surgeons apply some form of instrumentation to prevent movement between the vertebrae. Instrumentation protects the graft so it can heal better and faster. One option involves screwing a strap of metal across the front surface of the spine over the area where the graft rests. A second method involves additional surgery through the low back, either on the same day or during a later surgery. In this operation, metal plates and screws are applied through the back of the spine, locking the two vertebrae and preventing them from moving. By locking the vertebrae from the front and back, some surgeons believe the graft stays solid and is prevented from collapsing. Results do show improved fusion of the graft. Debate is present on whether patients fare as equally well with other methods of fusion.
With all spinal fusion surgeries, the fusion itself is not completed at the time of surgery. Instead, the conditions for the spine to fuse are created and the fusion will set up over a 3 to 6 month (and up to 18 month) period of time following the spinal surgery.

*Preoperative Rehabilitation***:** Preoperative treatment is to establish a conditioning program for surgery. Included in the program is keeping the affected joint from excessive mechanical forces and instruction on proper postural body mechanics for everyday movement and an exercise program to improve flexibility and core strengthening. Medications such as non-steroidal anti-inflammatory drugs, acetaminophen, muscle relaxants, and possibly narcotics are prescribed for pain control. Spinal injections can be used for both treatment and diagnostic purposes. There are several different types of spinal injections. These injections usually use a mixture of an anesthetic and some type of cortisone preparation. The anesthetic numbs the area where it is injected. If the injection takes away the pain immediately, this reveals important information suggesting that the injected area is indeed the source of pain. The cortisone decreases inflammation and can reduce the pain from an inflamed nerve or joint for a prolonged period of time. Types of injections include; epidural steroid injection (ESI), selective nerve root injection, facet joint injections, and trigger point injections

POSTOPERATIVE REHABILITATION

Note: The following rehabilitation progression is a combination of guidelines provided by O'Sullivan,Bardin, Kim and Todd. Refer to their publications in the reference section to obtain details.

Part I: At the Hospital: one to five days

Goals: Control pain
Protect repair
Instill proper alignment through positioning and controlled movement

Intervention:

- TLSO brace to ensure minimal lumbar motion with routine movement.
- Educate and demonstrate controlled mobility with neutral spine precautions for function (bed mobility, transfers, gait)
- Bed level and bedside exercises to address muscular atrophy, i.e: quad sets, glut sets, heel slides, mini-squats, heel raises.

Part II: After discharge: Post-Op to 6-8 weeks

Goals: Continue to control pain
Continue to protect fusion
Increase endurance

Intervention:

- Reinforce neutral spine/proper body mechanics with all functional activities
- Encourage low impact aerobic activity, i.e. walking, swimming
- Gentle active neural mobilization, SLR and progressive walking program

Part III: Outpatient physical therapy reconditioning program - 3 phases

Phase I: Cognitive stage: 3-6 weeks

Goals: Pain and inflammation control
Kinesthetic training for maintaining neutral spine
Activation of transverse abdominus and multifidi muscles in sitting and standing
Demonstration of proper body mechanics with all functional activities (sitting, standing,

bending, lifting)
Improve flexibility of the hip and region

Intervention:

- Ice, electrical stimulation, soft tissue mobilization if indicated
- Education and continued practice of obtaining and maintaining neutral spine
- Dynamic lumbar stabilization exercises
- Functional activities training in proper alignment
- Active and passive stretches for the lower extremities

Phase II: Motor learning stage: (8 weeks – 4 months before becoming automatic)

Goals: Spontaneous activation of 'internal corset' with all dynamic activity
Progress dynamic lumbar stabilization
Progress aerobic activity (speed, length, and duration)
Sport simulation/controlled environment

Intervention:

- "Core" trunk strengthening
- Extremity strengthening – while maintaining a neutral trunk alignment
- Functional training
- Treadmill walking, elliptical rider, bicycle, swimming.

Phase III: Autonomous stage: (On-going)

Goals: Return to high level/high intensity activities for prolonged periods of time

Intervention:

- Work hardening/conditioning
- Dynamic co-ordination and balance activities

These post-surgical exercises are the same exercises used to prevent surgery and have been shown to be an effective treatment with long-term reductions in pain and functional disability in subjects diagnosed with lumbar segment instability and chronic low back pain. For operative or for non-operative patients the approach is the same, it is based on a motor learning model where faulty movement patterns are identified and components of movement are isolated so they can be retrained into functional tasks.

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