

Internal Fixation of Posterior Spine With Interbody Fusion

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Posterior lumbar laminectomy with interbody fusion and the use of bone plates and pedicle bone screws is a rapidly growing surgical technique. Since the early 1900s, there has been a continual growth and development in internal fixation components as a treatment for spinal diseases.

Historically, orthopedic surgeons and neurosurgeons have shared the work on spinal problems. Orthopedic surgeons are concerned with spinal deformities while neurosurgeons traditionally work on problems inside the dura and structural problems that compromise the spinal cord or nerves. Both types of surgeons treat disk disease and disk herniations. Today these lines are more obscure. Spinal problems are most prevalent in today's society. Understanding the spine and its function and patient complaints has become a fulltime subspecialty.

Spinal Anatomy

There are 33 vertebrae, including 7 located in the cervical region, 12 in the thoracic region, 5 in the lumbar region, 5 in the sacral region, and 4 in the coccygeal region. The vertebral body's function is to bear weight, as in standing or sitting. The disk, made of a fibrous elastic cartilage, cushions the vertebrae, lubricates the joints between the vertebrae, and acts as a shock absorber. The lumbar vertebrae are strong and massive. The anterior part of the vertebrae (except the first two cervical vertebrae) consists of a body and the posterior part.

The posterior part consists of two pedicles, two laminae, and seven processes projecting from the laminae. The two pedicles are short, thick pieces of bone that arise laterally from each vertebral body and project backward (Figure 1). The pedicle of one vertebra lies adjacent to those of another vertebra. They are arranged to form a foramen for an opening through which the spinal nerves emerge. The laminae are two broad plates of bone connected to the vertebral body by the pedicles and fused together to form the spinal canal. The seven processes are two superior articulating processes directed inward instead of upward, two inferior articulating processes directed outward instead of downward, and one short, blunt spinous process that projects backward from the junction of the two laminae and serves as the attachment of muscles and ligaments.^{1,3}

Patient Selection

Before surgery is considered, all conservative treatments must first be exhausted. These may include medication, physical therapy, or

psychological evaluation. Extensive study of the patient's spine utilizes the many available diagnostic means, but not all studies must be done on all patients. Weight-bearing films are a necessity; however, depending upon the suspected pathology, computed tomography (CT), magnetic resonance imaging (MRI), or myelogram/CT scan may be indicated.

Surgery offers relief when conservative methods are unsuccessful. Surgical intervention is reserved for those patients diagnosed with conditions such as herniated disk, spondylolisthesis, degenerative disk disease, and spinal cord compression. Surgery can leave the patient with postoperative problems and complications. Cloward strongly believes that "discectomy may cure sciatica but not relieve lower back pain and decompressive laminectomy may leave the patient with painful instability and nerve root scarring."⁴ The explanation for spinal fusion is founded on the concept that painful symptoms can be eliminated by restricting motion across the degenerated or unstable

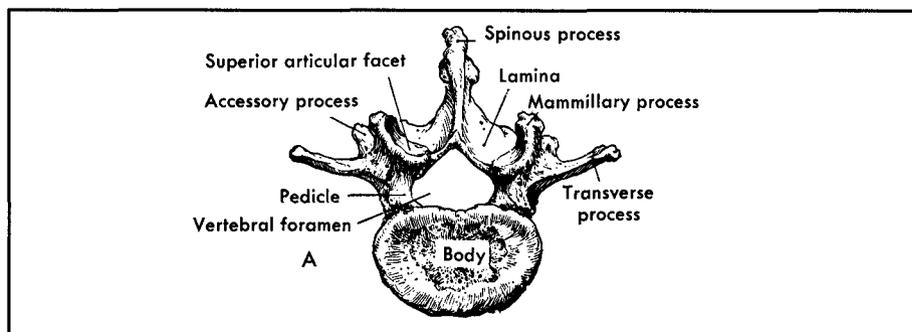


Figure 1. Fourth lumbar vertebra from above. (Copied with permission from Meeker MH, Rothrock JC. *Alexander's Care of the Patient in Surgery*. 9th ed. St Louis, Mo: Mosby-Year Book, Inc; 1991:707.)

spine; however, spondylolisthesis, non-union, or failed bone graft may result. These complications increase the need to stabilize the spine with implants.⁴

Possible contraindications to internal fixation include factors related to a patient's health and lifestyle, such as amount of physical activity, alcohol or drug abuse, mental illness, morbid obesity, cancer, systemic or localized infection, kidney dialysis, or osteopenia.^{1,5-6} John Zinkel, MD, neurosurgeon, lists two contraindications to this procedure: staphylococcal infection or bone that is too brittle to hold the screw.⁷

In 1910, Lane bolted plates onto the spinous processes to stabilize traumatic injuries. Since that time, the concept of screw placement to stabilize the spine has continued to advance.¹ Selective stabilization of the spine with bone plates and screws has developed. Since the 1940s, transpedicular spine instrumentation has gained in popularity as a treatment of various types of spinal deformities and injuries. By using bone plates and pedicle bone screws in conjunction with posterior lumbar interbody fusion, surgeons are able to perform extensive, destabilizing nerve root decompressions to increase pain relief. The surgeon can restore stability to the surgically destabilized spine with plates, screws, and bone graft.⁸⁻¹⁰

Pedicle screw systems are currently in various stages of development, investigation, and use. The FDA has approved bone plates and screws for use in the anterior spinal column, cervical spine, sacrum, and iliac. There is a 510K FDA approval of bone plates and bone screws for use in bone, but not specifically as "pedicle screws".¹¹ Although the screws can be used as the surgeon sees fit and they can be used in the posterior lumbar pedicle, they are not currently called "pedicle screws". This is very technical since all orthopedic screws and plates are approved as bone plates and screws not for specific area usage, such as internal fixation systems that can be used in the tibia, ulna, or fingers.¹²⁻¹⁴

Operating Room Preparation Room preparation for posterior

lumbar internal fixation and fusion is extremely important. Basic room equipment includes an electric operating room table (that has been turned so a C-Arm can move more freely), a lumbar frame, foam padding (that covers the table and frame), and a head holder with pins. Also needed are a 6-ft table, a five-foot table, Mayfield table, prep table, Mayo stand, double ring stand, suction and cautery, as well as Malis bipolar cautery, nitrogen cord, and pedal for the air-powered equipment (Anspach). A fiberoptic head light is needed. A microscope is set up and available in the room. Intraoperative cross-table lateral x-rays are taken with the C-Arm during screw placement; therefore, two x-ray shields are needed for operating room personnel.

If possible, all the equipment is brought into the room and arranged the night before surgery to facilitate starting the procedure. A case cart system containing sterile supplies and instrumentation is used. The implant instrumentation and implants are placed on a separate cart.

The day of surgery, the room is opened by the scrub person and the circulator. The x-ray monitor, bionics, and cell-saver equipment are set up. The scrub person scrubs and arranges the instruments, sutures, and sponges on the six- and five-foot tables and drapes a Mayo stand to place the drapes on. After the patient has been positioned, the C-Arm is brought into the room. Once the stretcher is out of the room and x-ray films are taken to determine resolution and lumbar position, the Mayfield drape and prep tray are opened.

Patient preparation for this procedure is extensive. A central line and an arterial line is inserted prior to bringing the patient to the room for internal blood pressure and to draw labs. Once the patient is brought into the room, an electrocardiogram (ECG) monitor, blood pressure cuff, and pulse oximeter are put on the patient. An antibiotic (2 gm of both cefazolin sodium and methylprednisolone sodium succinate) is given via intravenous pyelogram (IVP). Sensory evoked poten-

tials (SEP) and electromyography (EMG) needles are placed under the skin to monitor nerve schema. The objective in evaluating peripheral and central neural pathways is to assess spinal cord function intraoperatively and to protect the cord from injury during surgery. A narcotic-based anesthetic used with low concentrations of inhalation agents is preferred. High concentrations of inhalation agents can affect the amplitudes. The patient is not fully paralyzed because some muscle function is necessary. The patient is anesthetized while on the stretcher. Body temperature is maintained by using a fluid warmer, patient body warming blanket, or a breathing circuit. Strict input and output must be calculated. Input includes infusion of intravenous fluids and blood products. Output includes blood loss and urine output. While the patient is being intubated, a Foley catheter is inserted and sequential stockings are put on the patient. The head holder is applied to the patient, who is then turned onto the operating room table. The conductive plate is put on the posterior thigh.

The patient's head is suspended in a craniotomy-type head holder to avoid pressure upon the face and nose. The arms are positioned, with the left arm padded and placed next to the patient's side and the right arm carefully put on a padded arm-board at a 90-degree angle. This position allows the C-Arm to move freely from the head (where it is kept during the procedure), to the sacrum when x-rays are required. The knees are padded and the feet are elevated and placed upon a roll. A man's genitals or a woman's breasts are checked to be free from pressure and skin folds. The lumbar frame allows for the abdomen to hang free. The C-Arm is moved down to check the resolution and lumbar position. The Mayfield table is draped and set up and then the patient is prepped. Only new bottles of povidone-iodine scrub and solution are used. After a 10-minute scrub, the assistant changes gloves and applies the solution.

Draping is the surgeon's preference but may include four sticky



Figure 2. Surgical setup demonstrating isolation drape and C-Arm position (Bon Secours Hospital).

towels, two 3/4 sheets at the feet, one 3/4 sheet on each side, and one 3/4 sheet at the top with staples to secure drapes. An iodine-impregnated incision drape is then placed over the incisional area. Next, three isolation drapes are used. The first two are secured to the patient laterally with the staples then placed over each end of the C-Arm. The drape is tied in place with a sterile gauze roll. The excess drape remains at the head of the table to allow C-Arm movement into the sterile field. The third drape is secured with four large drape clips to an isolation pole, which isolates anesthesia from the field. The lower edge of this drape is attached to the 3/4 drape with staples; the lower sides of this drape are also tied to the C-Arm (Figure 2). The pediatric laparotomy sheet is placed over these drapes. The Mayfield table is then brought up to the field and the drape is secured to the patient's legs. The light handles are put on and the cell saver anticoagulation tubing is attached with a small drape clip over the top of the isolation bar. The cords to the electrical surgical unit, Malis, and suction are placed off the patient's left side and attached to the drape with a non-penetrating towel clamp. The air-powered equipment cord is dropped off the patient's right side

and is also attached to the drape with a non-penetrating towel clamp and connected to the foot pedal. Four instrument pouches are used. One is placed near the patient's incision for the electrical surgical unit, Malis, and suction. Three labeled instrument pouches, into which the Kerrison and pituitary rongeurs are put, are placed on the edge of the Mayfield table. Large lap sponges are used to start the case.

Instrumentation

Surgical instrumentation for a decompressive lumbar laminectomy is basic and includes knife handles Nos. 3, 4, and 7; straight and curved Mayo scissors; Cushing periosteal elevators; Sunday elevator; Leksell rongeurs with wide and narrow jaws; Kerrison rongeurs in a variety of sizes from 2 mm to 5 mm; straight and upbiting pituitary rongeurs ranging from 2 mm to 6 mm; and Gelpi, Weitlaner, Meyerding, and Langenbeck neuroretractors (Figure 3). On a lumbar decompression with interbody fusion a Balfour retractor with small and large interchangeable side blades is used. Air-powered equipment with a 7.5 and 8 blue tip burr will be used during the case.

At Bon Secours Hospital, we use the Acromed system. The implants are uncomplicated. Special instrumentation for the pedicle screw placement and the interbody diskectomy includes curettes, osteotomies, chisels, and small and large Cobb elevators in a variety of sizes with extra long (1-in.) handles.

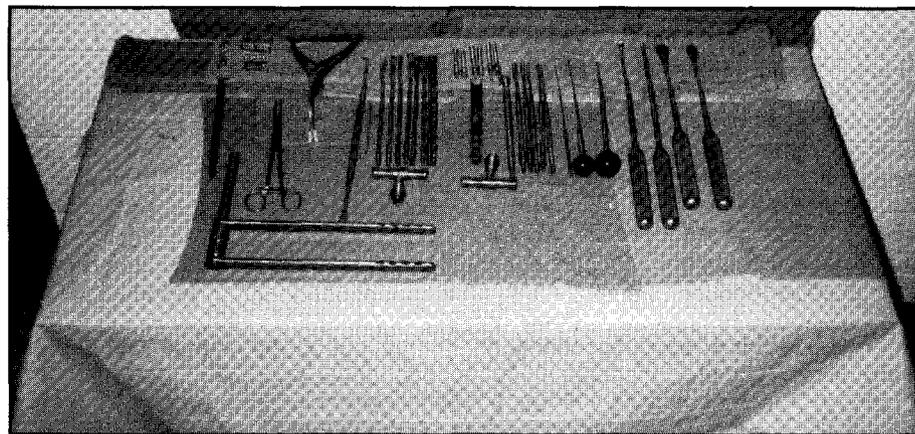


Figure 3. Basic surgical instrumentation for procedure.

Instrumentation unique to the insertion of pedicle screws include the following:

- Three foramina probes
- Sounding probe
- Bone probes
- Modular "T" handles
- Bone taps (diameter sizes 5.5 mm to 8.5 mm)
- Self-retaining screw wrenches (1/8 in.)
- Screw wrench (1/8 in.)
- Nut wrenches (5/16 in. and 3/8 in.)
- Side handle wrenches (5/16 in. and 3/8 in.)
- Screw gauge
- Screw alignment rods

Instruments for the interbody diskectomy include the following:

- Disk shavers (sizes 8 mm to 15 mm)
- Straight spreaders (sizes 8 mm to 14 mm)
- Tapered spreaders (sizes 8 mm to 6 mm to 14 mm)
- Modular "T" handles

Instrumentation for the interbody fusion includes screw distracter, double-ended impactor (round ends, square ends), and graft holder. There are plate benders, tubular benders, in-situ benders, cannulated screw cutters, and a variety of contouring templates, rods, nuts, washers and screws. The implants include screws, plates, locking nuts, and a transverse rod connector. Each screw has a cancellous and machine thread portion with an integral nut (Figure 4). The diameter of the screw ranges from

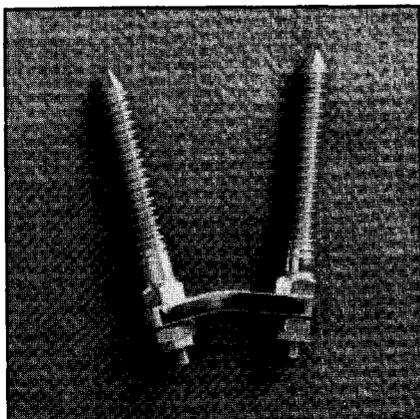


Figure 4. Screw implant.

5.5 mm to 8.5 mm and the length of the cancellous thread from 35 mm to 50 mm. The plates are designed with nested slots and variable lengths.¹

The surgical technologist must become familiar with the implants, the instrumentation, and the order of the surgical procedure; this will greatly assist the surgeon and facilitate this extensive surgical procedure.

Medications

The only medications on the field is triple-antibiotic irrigation solution used for the bone graft to wash out the blood from sponges and to irrigate the wound. Thrombin is used with absorbable gelatin. Morphine sulfate is injected before wound closure.

Surgical Procedure

Internal fixation combined with interbody fusion is carried out with the following steps:

Decompression. A midline incision is made over the spinal area to be fused. The incision is extended far enough to assure good exposure. Initially, Gelpi retractors are used. Deeper retractors are used as needed as the tissue is dissected down to the spinal process. Pencil cautery and Cobb elevators are used for the dissection. Subperiosteal dissection of paravertebral muscles is done to expose the spinal process and laminae. A cross-table lateral x-ray is taken to make certain the vertebral bodies involved are exposed. The spinous process and lamina are removed, thereby exposing the

spinal cord. A facetectomy is performed at this time to relieve the pressure on the nerve roots and to expose the disk space deep in the foramen. Bleeding is to be expected when the nerve roots are decompressed.

Pedicle technique. Using a small burr, the transverse process is cleaned off. The surgeon identifies the entry point of the pedicle and makes an entrance point with either a burr or a bone probe. A lateral x-ray is taken to confirm the position of the pedicle. The surgeon probes the pedicle with the pedicle sound. The pedicle is tapped beginning with a 5.5-mm diameter cancellous tap in sequence to the size below the screw size to be used. Sacral screws are tapped up to the exact size of the screw. The screw is inserted into the most anterior aspect of the vertebral body. An x-ray is taken to verify the position. This process is followed for all screws that are to be inserted. A single-level fusion has four screw insertions; two screws fused above the vertebral body and two fused below. A diskectomy is performed when all screws have been inserted.

Diskectomy. A diskectomy is done to ensure the success of the bone graft. The surgeon uses the

screw distracter to open the vertebral bodies. Therefore, dissection is done to allow access to the vertebral body to remove all disk material and to expose the bone plate. The ligamentum flavum is incised with a No. 11 knife blade. The tissue is removed with a pituitary rongeur. Using the shavers specifically designed to remove disk, the surgeon starts with an 8-mm shaver, followed by the pituitary rongeur and large curette to remove disk. The shaver size is increased in sequence alternating with the pituitary rongeur and large curette. Once one side is completed, the surgeon will repeat the process on the other side of the vertebral body.

Bone Graft. The surfaces of the vertebral body, transverse spine, and lateral aspects of the superior facets should be decorticated to ensure a surface to which the bone can adhere and graft. The bone can be an autograft, taken from the patient's iliac crest or from bone saved during the laminectomy. Allograft or a combination of autograft and allograft may be used depending on the amount of bone needed. Cortical and cancellous bone can be used. The vertebral body is separated using the screw distracter. Small pieces of bone are

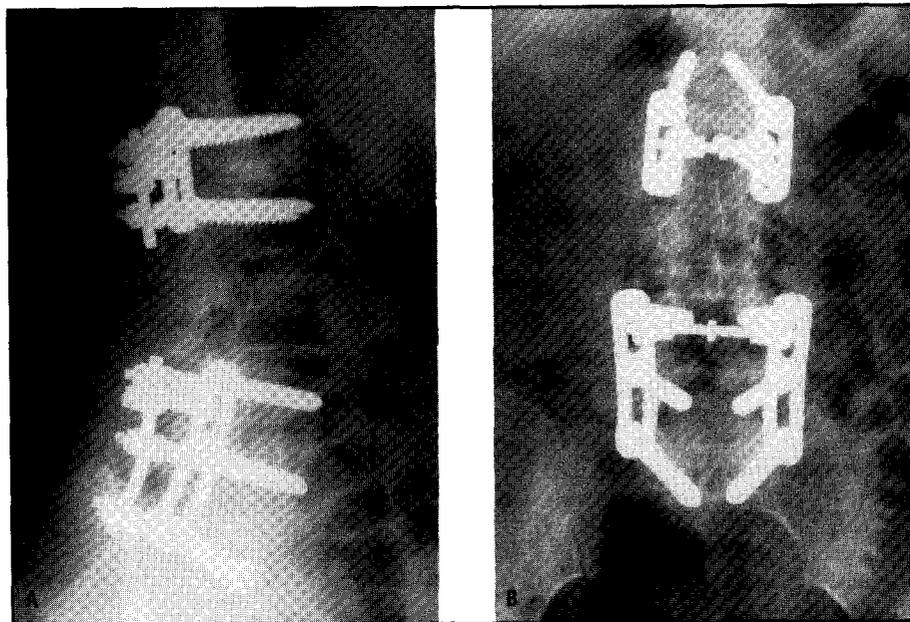


Figure 5. X-ray film of 3-level lumbar internal fixation of 69-year old female with bone plates, pedicle bone screws, and cross-connector implants. A, Right, lateral view; B, Posterior view (Bon Secours Hospital).

removed and placed between the vertebral bodies using long Russian forceps. Using a double-ended impactor and mallet, the bone is packed into the decorticated spaces. This process is continued until the surgeon is satisfied with the fusion. It is then repeated on the other side of the vertebrae.

Plating. A bone plate is placed on each side of the spine onto the machine thread portion of the screws and over the bone graft. The bone plate can be shaped if needed. The screw nuts are then threaded onto the screws. The 3/8-in. nut wrench is used to move down the nut; the 3/8-in. side handle wrench with a 1/8-in. self-retaining wrench is then used to torque the nuts. The process is performed on each screw. The 5/16-in. locking nut is placed on each screw and locked into place using the 5/16-in. side handle wrench. Again, the 1/8-in. wrench is used to hold the screw stationary while the nut is torqued. The screws are shortened with the cannulated screw cutter. A cross connector may be applied for additional stabilization and the interlinking of the plates (Figure 5). The remaining bone is put around the plate. The surgical wound is then irrigated with a triple-antibiotic solution, the dura is injected with 0.5 cc of morphine sulfate, and absorbable gelatin with thrombin is placed over the dura. A closed drain system is put into the wound. The incision is then closed. An antibiotic ointment is placed around the drain site and the dressing is applied.

Postoperative Care and Complications

The patient is placed on a bed and taken to PACU or ICU depending upon the number of levels fused and the length of the surgery. The ICU stay varies from 1 to 3 days followed by a 3- to 5-day stay until the patient is ambulatory without intravenous or intramuscular narcotics.

The most important aspect of successful bone healing is a patient's ability and willingness to follow the postoperative instructions, which include not smoking and limiting physical activities that put stress on the implants. It takes 1

to 3 months for the fusion mass setup, 3 to 6 months to calcify and to be able to share weight bearing with the implant. The patient is x-rayed at 1 month, 3 months, and then every 3 months for 1 year.

As with any surgical procedure, there are potential drawbacks to this procedure. Acro Med lists the following possible adverse effects: non-union or delayed union, bending or fracture of implant, loosening of implant, metal sensitivity or allergic reaction to a foreign body, infection, pain, and nerve damage due to surgical trauma and bursitis.^{1,7}

There is no substitute for a strong and healthy spine but internal fixation with interbody fusion offers the patient a solution to painful back problems. This surgical technique provides sufficient stability and rigidity to the operated spine until fusion takes place. Δ

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