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Spinal Artificial Disc Replacement: Lumbar Arthroplasty

Part II

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Learning Objectives: *After reading this article, the participant should be able to:*
1. Describe the criteria for patient selection for lumbar arthroplasty.
2. Explain the surgical technique for artificial disc replacement in the lumbar spine.
3. Describe postoperative management of patients undergoing artificial disc replacement in the lumbar spine.

This article is the second of two parts.

Surgical Indications for Lumbar Artificial Disc Replacement

Indications for artificial disc replacement (ADR) are still being developed for each of the different devices. Table 1 lists inclusion and exclusion criteria for the procedure. Currently, lumbar disc arthroplasty is indicated in skeletally mature patients for one-level degenerative disc disease at L4–S1 by use of the Maverick (Medtronic Sofamor Danek) and Charité (DePuy Spine) devices; at L1–S1 with the FlexiCore device (Stryker Spine); or for one- or two-level disease at L3–S1 with the ProDisc (Synthes Spine Solutions, Inc.). The ideal candidate for artificial disc replacement surgery has low back pain of discogenic origin with no significant facet joint changes, no previous fusion surgeries or other operations involving the facet joints at the level in question, no canal stenosis, and no more than 3 mm of spondylolisthesis. The patient should have received at least 6 months of conservative treatment with unsuccessful results.

Because the nerves usually are not decompressed completely during the arthroplasty procedure, limited radiculopathy pain may or may not be relieved by disc and neuroforamen height restoration. Restoration of normal motion may worsen radicular pain if a posteriorly herniated disc or foraminal stenosis continues to impinge on the nerve root.

Bertagnoli et al. defined the ideal candidate for the Charité artificial disc as having single-level degenerative disc disease, disc height greater than 4 mm, no osteoarthritic changes of the facets, no adjacent level degeneration, and intact posterior elements. The Charité Center for Musculoskeletal Surgery (Berlin, Germany) has reported, in 17 years of long-term follow-up, that incorrect preoperative indications were responsible for 56% of poor clinical outcomes at that center. The authors concluded that arthroplasty is not indicated for advanced disc degeneration or spondylolisthesis.

Technique of Lumbar Artificial Disc Placement

All of the artificial discs have some device-specific nuances for insertion. This description is general and clearly

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The authors have disclosed that the use of all the artificial discs described in this article, with the exception of the Charité SB III, for the treatment of lumbar discogenic pain has not been approved by the U.S. Food and Drug Administration.

Wolters Kluwer Health has identified and resolved all faculty conflicts of interest regarding this educational activity.

Category: Spine

Key Words: Artificial disc replacement, Surgical indications, Lumbar arthroplasty, Spine surgery

Table 1. Inclusion and Exclusion Criteria for Artificial Disc Replacement

	Charité	ProDisc	Maverick	FlexiCore
Inclusion criteria				
Age (years)	18–60	18–60	18–70	18–60
Level	L4–S1, single	L3–S1, two levels	L4–S1, single	L1– S1, single
Oswestry disability index score	> 30/50	> 20/50	≥30/50	≥40/50
Visual analog score	> 40/100	—	≥20/100	≥40/100
Failed conservative treatment	≥6 months	≥ 6 months	≥6 months	≥6 months
Axial pain	Yes	Yes	Yes	Greater than leg pain
Radiculopathy	Yes*	Yes	Yes	Yes
Exclusion criteria				
Previous fusion	Yes	Yes	Yes	Yes
Spondylolisthesis	>3 mm	>3 mm or 5 degrees	Yes	>4 mm
Scoliosis	>11 degrees	—	—	>10 degrees
Facet joint arthrosis	Yes	Yes	Yes	Yes
Stenosis	—	< 8 mm	Yes	Moderate/severe
Osteoporosis	Yes	> 2.5	Yes	Yes
Metal allergy	Yes	Yes	Yes	Yes
Obesity	Yes	Yes	—	Yes
Autoimmune disease	Yes	Yes	Yes	Yes
Steroid use	Yes	Yes	Yes	Yes

* Without nerve root compression.

cannot replace proper surgical training for insertion of each type of disc.

Implantation of any artificial disc begins with preoperative planning. The correct component size usually is estimated prior to surgery by use of CT or MRI scans to select appropriate footprint sizes.

The patient is positioned on the operating table in the supine position with arms across the chest and the affected levels of the spine over the table break. The ability to adjust the table (to flex or extend the spine by "breaking" the bed) during the arthroplasty procedure sometimes makes it easier to implant the device. A left retroperitoneal approach (Fig. 1) is usually chosen. A 4- to 6-cm incision is made, and the dissection is carried down through the subcutaneous tissue. The rectus sheath is exposed and divided, and the peritoneum is dissected from the fascia transversalis for 2 to 3 cm in both directions. The retroperitoneal space is entered lateral to the psoas muscle. The posterior sheath is divided, and, using blunt dissection, the ureter and abdominal contents are dissected away from the iliac vessels. After the iliac vessels are carefully exposed, the joint space of the vertebral bodies is accessed (L5–S1 at the bifurcation; Fig. 2A), L4–L5 between vessels is retracted to the right, and the sympathetic chain is retracted to the left (Fig. 2B). The central sacral vessels are ligated and divided for the L5–S1 exposure.

The Omni retractor (Omni-Tract Surgical) is used to provide complete side-to-side exposure of the intervertebral space. The anterior intervertebral disc tissue blunt dissection is performed. The operative level and vertebral body midline are confirmed using anteroposterior (AP) fluoroscopy. The anterior longitudinal ligament is then either excised completely or incised superiorly and laterally and reflected inferiorly for later reapproximation and suturing. Although, in theory, better spinal segment biomechanics could be restored by reconstruction of the anterior longitudinal ligament, most surgeons have found this technique

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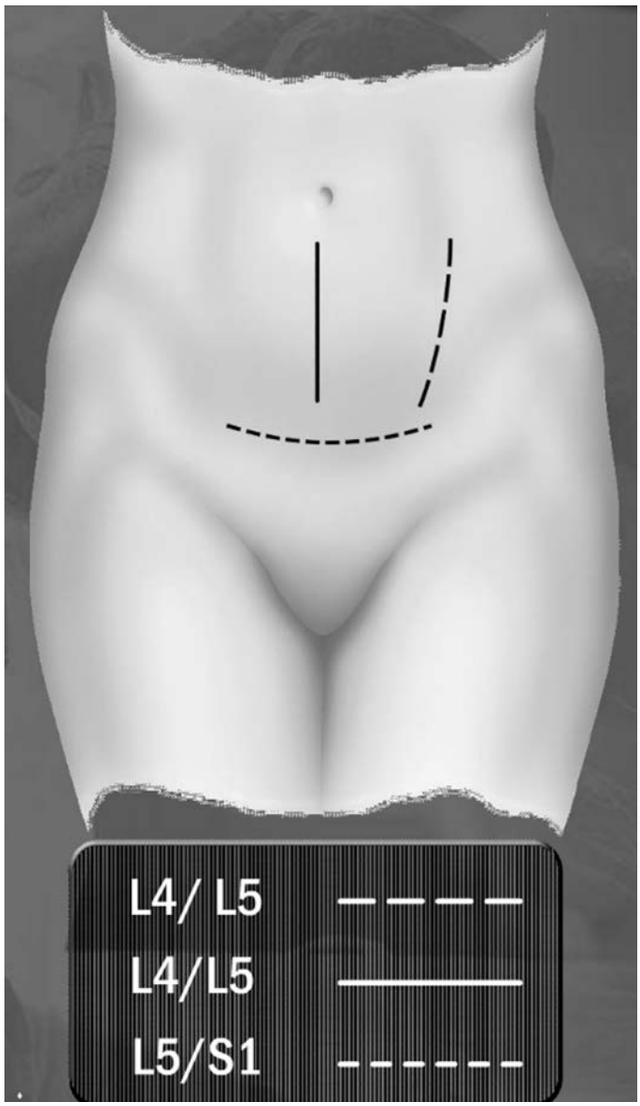

Figure 1. A left retroperitoneal approach incision (*solid line*) and dissection (*dotted lines*) carried down through the subcutaneous tissue.

both difficult and of limited usefulness. An attempt is made to preserve the lateral portion of the annulus. A complete discectomy is performed using straight, angled, and ring curettes and Kerrison rongeurs. The cartilaginous endplates from the superior and inferior endplate surfaces also are removed. Extreme care is taken not to damage the bony endplates or encroach into the vertebral body. A rongeur is used to remove the anterior ridge of the vertebral body, the posterior ridge, and the dorsal and ventral osteophytes. A disc elevator, sharp Cobb elevator, or osteotome sometimes is used for this and also to loosen the disc material from the endplate surface and shave it down flat.

Carefully controlled distraction is performed in a variety of ways, depending on which device is being inserted. Care is taken to achieve adequate and parallel distraction, thus restoring the height of the disc and neuroforamen. Further meticulous removal of any residual disc material is verified, with special attention paid to the posterior lateral corners. The posterior annulus usually is released using an angled curette or similar instrument, with the position of the instrument confirmed on lateral fluoroscopy.

Some type of endplate sizing gauge usually is needed to size the endplates appropriately; this sizing also is confirmed using lateral fluoroscopy. Maximal coverage of the endplates should be achieved to reduce potential for subsidence. However, oversized endplates, especially those with square footprint designs, can cause neuroforaminal encroachment and postoperative radiculopathy.

At this point, it is very important to verify the precise midline of the vertebral body. Equal distances should be noted from the spinous process to the pedicles on AP fluoroscopy, and the spinous processes should be perfectly in line with one another (Fig. 3). Radiolucent trial sizers with various lordotic angles are used to select the appropriate

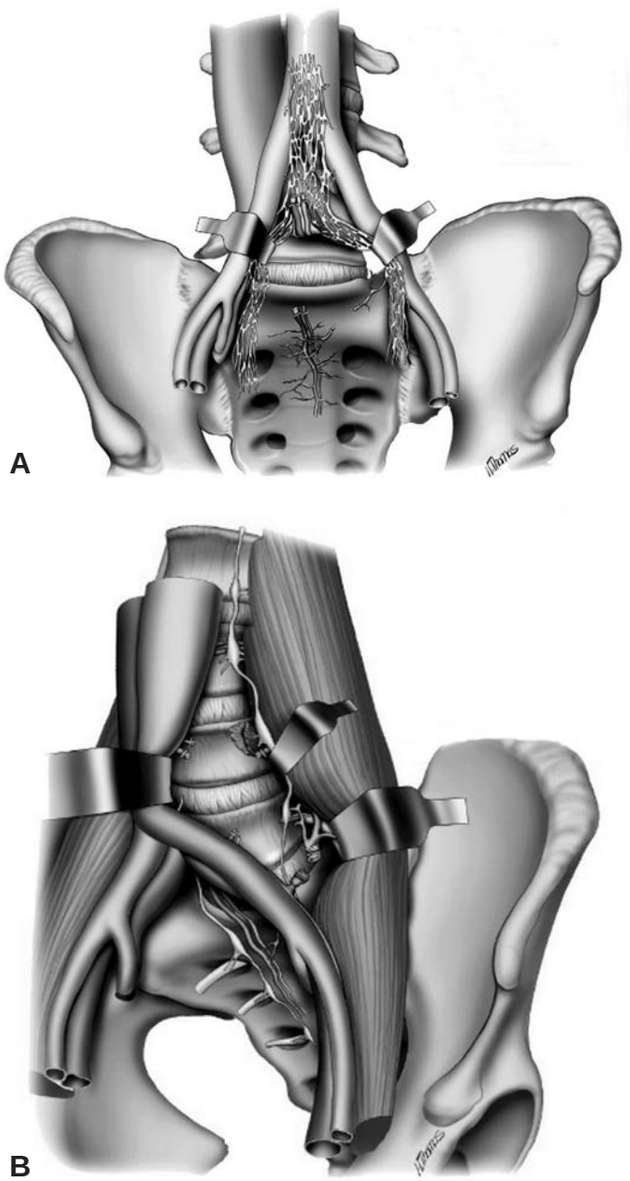

Figure 2. Exposure of the L5–S1 interspace at the bifurcation (*A*) and L4–L5 between vessels retracted to the right and the sympathetic chain to the left (*B*).

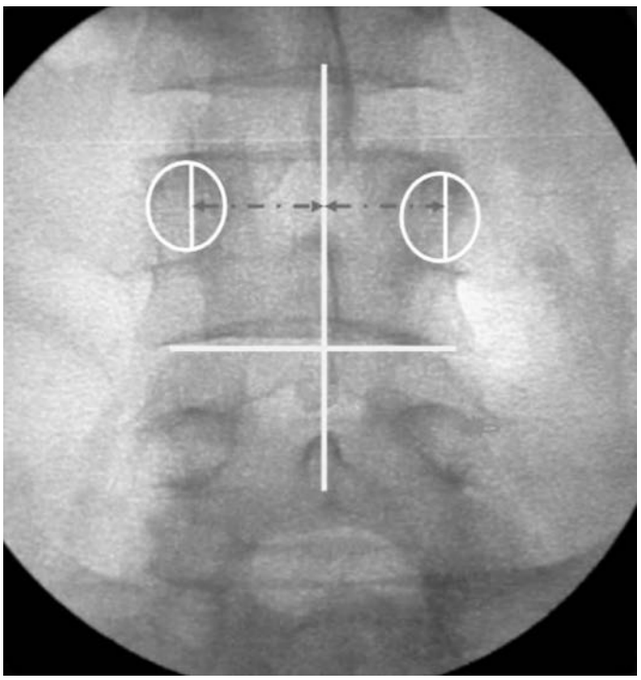

Figure 3. Anteroposterior (AP) fluoroscopic image during artificial disc replacement surgery showing equivalent distances from the spinous process to the pedicles, as used to verify that the image is truly in the AP plane. The spinous processes are perfectly in line with each other.

disc size, depending on the patient's anatomy and sagittal alignment. It is important to select the proper disc height and sagittal angle. Overdistraction of the disc space can have far worse consequences than loss of disc space height and could make it necessary to abandon the entire procedure and perform an anterior-posterior fusion. Degenerated discs usually are collapsed, and the vertebral column adapts to these new conditions over a period of time. If the selected disc height is too high, it could cause overstretching of the surrounding structures and lead to root stretch injuries, annular laxity, or implant failure in the long term. On the other hand, insufficient restoration of disc height can lead to overloading of the facet joints, with continued pain and, possibly, instability of the spinal column. All of the trial sizers have some type of marker to verify proper orientation both within the disc space and radiographically. For example, the Charité has a lateral "o" marker that represents the center of rotation and should be aligned on lateral fluoroscopy as a full circle 2 mm dorsal to the lateral midline (Fig. 4A) and a "+" sign that should align with the spinous process on AP fluoroscopy (Fig. 4B). The reasoning for this relates to the fact that the natural center of rotation in the spine lies at the two-thirds points of the disc space. Please see Part I of this article for more information.

After the correct size, angle, and position are ensured and the midline is verified, proper placement of the endplates of the artificial disc is ensured using a pilot driver. This step is important for all types of implants, but especially with the midline keel designs, because with this design the surgeon usually has only one chance to position the disc correctly. Parallel positioning of the pilot driver and, ultimately, the implant is required to restore normal biomechanics. The selected endplates are loaded and inserted into the disc space. FlexiCore and Maverick prostheses are inserted in one piece, which reduces placement error possibilities and lessens the amount of distraction required because with these ADRs, it is not necessary to implant the inner core separately after placement of the metal endplates. The posterior position of the device is verified again on lateral fluoroscopy. For three-piece implant devices, sliding cores are then correctly sized and placed under careful distraction. Adequate positioning of the entire prosthesis

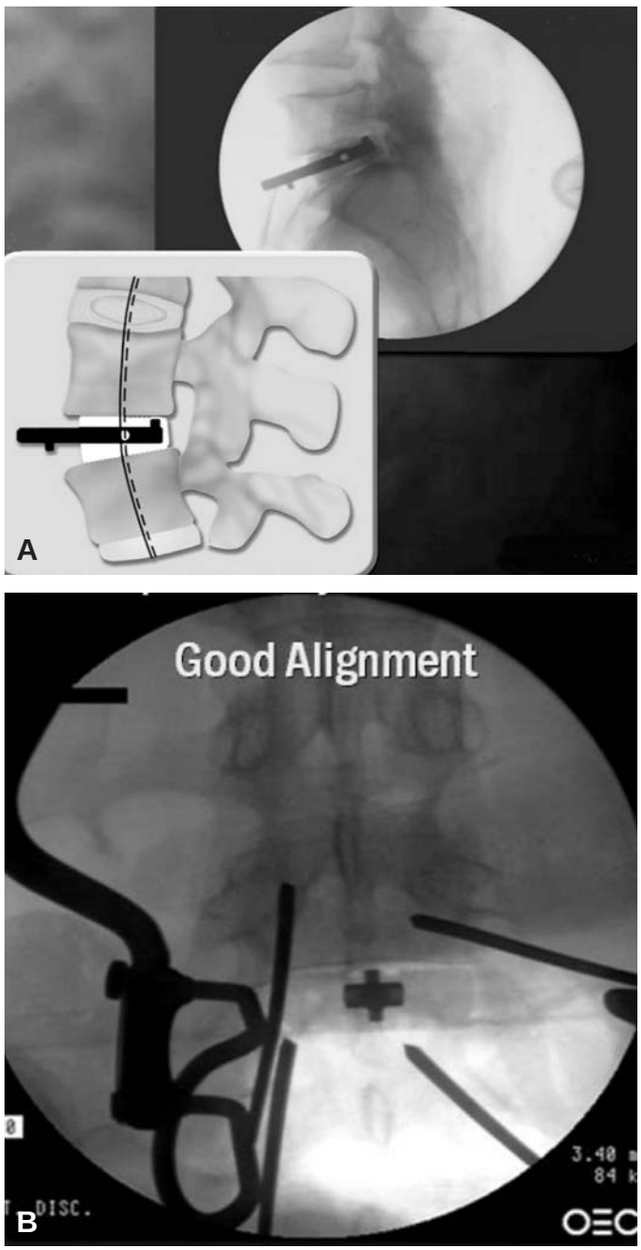

Figure 4. *A*, Lateral "o" marker used for the Charité represents the center of rotation, which should be aligned on the lateral fluoroscopy as a full circle 2 mm dorsal to the lateral midline. *B*, "+" sign on AP fluoroscopy verifies proper alignment with the spinous process in the AP plane.

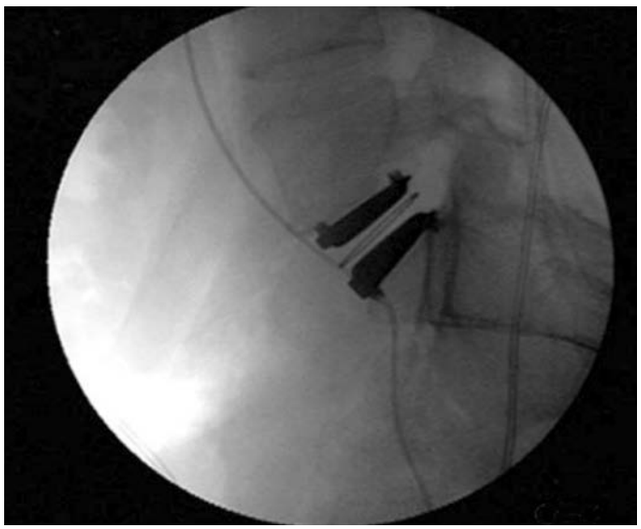

Figure 5. Intraoperative fluoroscopy confirming adequate positioning of the entire prosthesis.

(Fig. 5) is confirmed using intraoperative fluoroscopy. An impactor occasionally is used to make small adjustments and set the final location of the system at both upper and lower levels. Before the incision is closed, the status of the ureter and vessel should be verified.

Risks and Complications

Severe complications such as death, major bleeding, or severe nerve injury may be encountered. The risk of other complications, such as infection, minor bleeding, deep vein thrombosis, thrombophlebitis, ileus, or urinary retention, is approximately 5% to 10%. Male patients have a 2% to 10% risk of developing retrograde ejaculation, even when the operation is performed by an experienced surgeon.

Postoperative Management

Recuperation time after the arthroplasty procedure is comparatively short. In the multi-institutional FDA prospective randomized Charité artificial disc clinical trial, the mean hospitalization time was 3.4 days, and patients were able to return to work in 6 weeks, on average.

Physical therapy begins after the immediate postoperative period. Patients should begin to walk as soon as possible. Rehabilitation begins with abdominal flexion and active and passive hip and knee flexion exercises. After 4 weeks, physical therapy is directed toward maintaining mobility of the affected spinal levels, general conditioning, and strengthening. Lumbar spine rotation, side bending, and abdominal strengthening can begin at 6 weeks.

Some surgeons advocate that patients wear a lumbar corset for 3 months after Charité ADR and for 2 weeks after implantation of the ProDisc. This measure usually is not required after Maverick device implantation, because the Maverick has a large central keel. Patients should avoid lumbar hyperextension, heavy lifting, impact-loading activities, and twisting after implantation of the Charité and should avoid mechanical vibration or shock for about 3 months when the ADR has been performed with the Maverick device. Jumping, running, or contact sports are not recommended for 3 months, but swimming usually can begin after 4 weeks. The patient should be weaned from narcotic medication as early as possible.

Artificial disc replacement surgery represents an exciting area of rapidly advancing spinal technology. However, spine surgeons should be aware that definitive evidence of motion preservation at the operated level and protection of adjacent levels from increased degeneration await long-term outcomes from the prospective clinical studies. Patient selection criteria and skilled surgical technique will have a significant impact on results, now that artificial disc devices are becoming available for widespread use in the United States.

Readings

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I am very pleased to announce that retroactive to Volume 25, Issue 1, the American Association of Neurological Surgeons attests that this educational activity has been recognized for co-sponsored/endorsement for 1.5 Category 1 CME credits of the American Association of Neurological Surgeons' Continuing Education Award in Neurosurgery.

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1. The ideal candidate for Charité artificial disc replacement surgery has single-level degenerative disc disease, disc height greater than 4 mm, osteoarthritic changes of the facets, no adjacent level degeneration, and intact posterior elements.

   True or False?

2. CT or MRI is used to select appropriate footprint sizes before implantation of artificial discs.

   True or False?

3. The ProDisc artificial disc is the only device that may be considered for implantation at two levels.

   True or False?

4. Patients are required to undergo at least 6 months of conservative treatment with unsuccessful results to be eligible for artificial disc replacement surgery.

   True or False?

5. The joint space of the L5–S1 vertebral bodies is accessed using the Omni retractor and retracting the iliac vessels to the right and the sympathetic chain to the left.

   True or False?

6. Maximal coverage of the endplates should reduce potential for subsidence.

   True or False?

7. Overdistraction of the disc space during insertion of the device has far better consequences than loss of disc space.

   True or False?

8. FlexiCore and ProDisc prostheses are inserted in one piece, which reduces the amount of distraction required.

   True or False?

9. Patients should wear a lumbar corset for at least 2 weeks after implantation of the Maverick device.

   True or False?

10. The average time to return to work reported in the multicenter FDA prospective randomized Charité artificial disc clinical study was 6 weeks.

    True or False?

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