**Title:** Artificial Intervertebral Disc: Lumbar Spine  

**See also:** Artificial Intervertebral Disc: Cervical Spine

**Professional**
- Original Effective Date: August 9, 2005
- Revision Date(s): June 14, 2006; January 1, 2007; July 24, 2007; September 25 2007; February 22, 2010; March 10, 2011; March 8, 2013; June 23, 2015; August 4, 2016; May 23, 2018; July 17, 2019; August 21, 2020
- Current Effective Date: September 23, 2008

**Institutional**
- Original Effective Date: August 9, 2005
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<td>Comparators of interest are:</td>
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DESCRIPTION
Total disc replacement, using an artificial intervertebral disc designed for the lumbar spine, is proposed as an alternative to fusion in patients with degenerative disc disease leading to disabling symptoms.

Objective
The objective of this evidence review is to determine whether implantation of a lumbar artificial intervertebral disc improves the net health outcome in patients with degenerative disc disease.

Background
The most frequent cause of back pain requiring surgery, degenerative disc disease is common with age or trauma. Spine imaging, such as magnetic resonance imaging (MRI), computed tomography, or plain radiography, shows that lumbar disc degeneration is widespread but for most people does not cause symptoms. Potential candidates for artificial disc replacement have chronic low back pain attributed to DDD, lack of improvement with nonoperative treatment, and none of the contraindications for the procedure, which include multilevel disease, spinal stenosis, spondylolisthesis, scoliosis, previous major spine surgery, neurologic symptoms, and other minor contraindications. Patients who require procedures in addition to fusion (eg, laminectomy, decompression) are not candidates for the artificial disc.

When conservative treatment of degenerative disc disease (DDD) fails, a common surgical approach is spinal fusion. More than 200,000 spinal fusions are performed each year. However, the outcomes of spinal fusion have been controversial, in part due to the difficulty in determining if a patient's back pain is related to DDD and in part due to the success of the procedure itself. Also, spinal fusion alters the spine biomechanics, potentially leading to premature disc degeneration at adjacent levels, a particular concern for younger patients. During the past 30 years, various artificial intervertebral discs have been investigated as an alternative approach to fusion. This approach, also referred to as total disc replacement or spinal arthroplasty, is intended to maintain motion at the operative level once the damaged disc has been removed and normal biomechanics of the adjacent vertebrae.

Use of a motion-preserving artificial disc increases the potential for a variety of types of implant failure. They include device failure (device fracture, dislocation, or wear), bone-implant interface failure (subsidence, dislocation-migration, vertebral body fracture), and host response to the implant (osteolysis, heterotopic ossification, pseudotumor formation).

Regulatory Status
Three artificial lumbar disc devices (activL®, Charité®, ProDisc®-L) have been approved by the U.S. Food and Drug Administration (FDA) through the premarket approval process.
Production under the name Charité® was stopped in 2010 and the device with withdrawn in 2012.

Because the long-term safety and effectiveness of these devices were not known when approved, approval was contingent on completion of postmarketing studies. The activL® (Aesculap Implant Systems), Charité® (DePuy), and ProDisc®-L (Synthes Spine) devices are indicated for spinal arthroplasty in skeletally mature patients with DDD at 1 level. DDD is defined as discogenic back pain with degeneration of the disc confirmed by patient history and radiographs.

Table 1. U.S. Food and Drug Administration-Approved Lumbar Artificial Disc Devices

<table>
<thead>
<tr>
<th>Device</th>
<th>Manufacturer</th>
<th>Indication</th>
<th>PMA Number</th>
<th>Approval Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>activL</td>
<td>Aesculap Implant Systems, LLC</td>
<td>The activL® Artificial Disc (activL) is indicated for reconstruction of the disc at one level (L4-L5 or L5-S1) following single-level discectomy in skeletally mature patients with symptomatic degenerative disc disease (DDD) with no more than Grade I spondylolisthesis at the involved level. DDD is defined as discogenic back pain with degeneration of the disc confirmed by patient history, physical examination, and radiographic studies. The activL® Artificial Disc is implanted using an anterior retroperitoneal approach. Patients receiving the activL® Artificial Disc should have failed at least six months of nonoperative treatment prior to implantation of the device.</td>
<td>P120024</td>
<td>06/11/2015</td>
</tr>
<tr>
<td>ProDisc-L</td>
<td>Synthes Spine</td>
<td>The PRODISC®-L Total Disc Replacement is indicated for spinal arthroplasty in skeletally mature patients with degenerative disc disease (DDD) at one level from L3-S1. DDD is defined as discogenic back pain with degeneration of the disc confirmed by patient history and radiographic studies. These DDD patients should have no more than Grade 1 spondylolisthesis at the involved level. Patients receiving the PRODISC®-L Total Disc Replacement should have failed at least six months of conservative treatment prior to implantation of the PRODISC®-L Total Disc Replacement.</td>
<td>P050010</td>
<td>08/25/2006</td>
</tr>
<tr>
<td>Charite</td>
<td>Depuy Spine, Inc</td>
<td>The CHARITE Artificial Disc is indicated for spinal arthroplasty in skeletally mature patients with degenerative disc disease (DDD) at one level from L4-S I. DDD is defined as discogenic back pain with degeneration of the disc confirmed by patient history and radiographic studies. These DDD patients should have no more than 3mm of spondylolisthesis at the involved level. Patients receiving the CHARITE Artificial Disc should have failed at least six months of conservative treatment prior to implantation of the CHARITE Artificial Disc.</td>
<td>P040006</td>
<td>10/26/2004 Withdrawn 1/5/2012</td>
</tr>
</tbody>
</table>
A number of other artificial lumbar discs are in development or available only outside of the United States:

- The INMOTION® lumbar artificial disc (DePuy Spine) is a modification of the Charité® device with a change in name under the same premarket approval. The INMOTION® is not currently marketed in the United States.
- The Maverick™ artificial disc (Medtronic) is not marketed in the United States due to patent infringement litigation.
- The metal-on-metal FlexiCore® artificial disc (Stryker Spine) has completed the investigational device exemption trial as part of the FDA approval process and is currently being used under continued access.
- Kineflex-L™ (Spinal Motion) is a 3-piece, modular, metal-on-metal implant. An FDA advisory committee meeting on the Kineflex-L, scheduled in 2013, was canceled without explanation.

FDA product code: MJO.

**POLICY**

Artificial intervertebral discs of the lumbar spine are considered experimental / investigational.

**RATIONALE**

This evidence review has been updated with searches of the PubMed database. The most recent literature update was performed through March 2, 2020.

This review was informed by 3 TEC Assessments (2005, 2007, 2013).¹ ² ³

This review focuses only on artificial discs currently available in the United States. Evidence reviews assess the clinical evidence to determine whether the use of a technology improves the net health outcome. Broadly defined, health outcomes are length of life, quality of life, and ability to function, including benefits and harms. Every clinical condition has specific outcomes that are important to patients and to managing the course of that condition. Validated outcome measures are necessary to ascertain whether a condition improves or worsens; and whether the magnitude of that change is clinically significant. The net health outcome is a balance of benefits and harms.

To assess whether the evidence is sufficient to draw conclusions about the net health outcome of a technology, 2 domains are examined: the relevance and the quality and credibility. To be relevant, studies must represent one or more intended clinical use of the technology in the intended population and compare an effective and appropriate alternative at a comparable intensity. For some conditions, the alternative will be supportive care or surveillance. The quality and credibility of the evidence depend on study design and conduct, minimizing bias and confounding that can generate incorrect findings. The randomized controlled trial is preferred to assess efficacy; however, in some circumstances, nonrandomized studies may be adequate.
Randomized controlled trials are rarely large enough or long enough to capture less common adverse events and long-term effects. Other types of studies can be used for these purposes and to assess generalizability to broader clinical populations and settings of clinical practice.

**Clinical Context and Therapy Purpose**

The purpose of the lumbar artificial intervertebral disc is to provide a treatment option that is an alternative to or an improvement on existing therapies.

The question addressed in this evidence review is: Does implantation of a lumbar artificial intervertebral disc improve the net health outcome in patients with degenerative disc disease?

The following PICO was used to select literature to inform this review.

**Patients**

The relevant population of interest is individuals with lumbar degenerative disc disease.

Degenerative disc disease is defined as discogenic back pain with degeneration of the disc confirmed by patient history and radiographs.

**Intervention**

The therapy being considered is implantation of a lumbar artificial intervertebral disc.

Two artificial intervertebral discs are currently marketed in the U.S.: ProdiscL and activL.

**Comparators**

The following therapies are currently being used to make decisions about lumbar artificial intervertebral disc.

Relevant comparators are conservative therapy and lumbar spinal fusion.

Conservative treatment may include physical therapy, pharmacotherapy, epidural steroid injections, and many other modalities. The terms “nonsurgical” and “nonoperative” have also been used to describe conservative treatment. For example, professional societies recommend that surgery for lumbar spinal stenosis should be considered only after a patient fails to respond to conservative treatment, but there is no consensus about what constitutes an adequate treatment course or duration.

**Outcomes**

The general outcomes of interest are symptoms, functional outcomes, quality of life, and treatment-related morbidity.

Outcome measures for back surgery are relatively well-established (Table 2). These include back and leg visual analog scores to assess pain and the Oswestry Disability Index to assess functional limitations related to back pain. Broader functional status indices such as the 12-Item Short Form Health Survey or 36-Item Short Form Health Survey, particularly the physical function subscale of 36-Item Short Form Health Survey, are also used.
Table 2. Patient-reported Outcome Measures for Back Pain

<table>
<thead>
<tr>
<th>Measure</th>
<th>Outcome Evaluated</th>
<th>Description</th>
<th>MDD and MCID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oswestry Disability Score (ODI)</td>
<td>Disability Score (ODI)</td>
<td>Ten 5-point items; scores 0 (no disability) to 50 (totally disabled) or 0-100% of maximum score</td>
<td>MDD: 8-10 points MCID varies; often 15 points (30 percentage points).</td>
</tr>
<tr>
<td>Visual analog scale for back pain</td>
<td>Degree of back pain.</td>
<td>Patients indicate the degree of pain on a 0-100 scale</td>
<td>MDD: 2 points</td>
</tr>
<tr>
<td>Visual analog scale for leg pain</td>
<td>Degree of leg pain.</td>
<td>Patients indicate the degree of pain on a 0-100 scale</td>
<td>MDD: 5 points</td>
</tr>
</tbody>
</table>

MDD: minimal detectable difference; MCID: minimal clinically important difference.

Both short-term and long-term outcomes are important in evaluating back treatments. Net benefit should take into account immediate (perioperative) adverse events; improvements in pain, neurological status, and function at 12 to 24 months as measured by the Oswestry Disability Index, 36-Item Short Form Health Survey (SF-36), or visual analog scale measures; and 5-year secondary surgery rates, which reflect longer-term complications, recurrences, and treatment failures. Lumbar artificial disc devices are theorized to reduce the occurrence of adjacent-level degeneration, which has been observed after fusion more often than occurs naturally in nonfused segments; some RCTs have reported the occurrence of adjacent level degeneration at 5 years.

Patient preferences are important in decision-making about elective back surgery. In particular, to avoid the morbidity and risk of complications of the surgery, some patients may choose to prolong conservative treatments even if it means they have additional pain and functional limitation. Conversely, some patients will accept long-term outcomes of surgery similar to those of conservative therapy to get faster relief of symptoms and improvement in function. Patient preferences have not been compared in a systematic fashion.

Group means are commonly designated as primary outcome measures in spine studies. Variation in the calculation and definition of minimal clinically important difference makes it difficult to compare response rates across studies. Nevertheless, clinical trials should prespecify an minimal clinically important difference for Oswestry Disability Index and other measures when used, and report response rates in addition to group means.

The primary outcome in FDA regulated trials was a composite measure of success, which incorporates symptom improvement and absence of complications.

**Lumbar Artificial Intervertebral Discs**

**Review of Evidence**

**Randomized Controlled Trials**

Three RCTs have compared the treatment of degenerative disc disease using lumbar fusion with artificial lumbar intervertebral discs currently available in the United States. They include the pivotal trials for the ProDisc-L and activL discs, and a U.S. Food and Drug Administration (FDA) regulated trial of the ProDisc-L for 2-level degenerative disc disease. A fourth trial compared ProDisc-L with multidisciplinary rehabilitation. The composite success endpoint included improvements in Oswestry Disability Index scores (typically 15 points), improvement or maintenance in neurologic status, radiologic measures of range of motion, freedom from additional surgery, and freedom from serious device-related adverse events. Five-year outcomes
have been reported from the pivotal trials for both ProDisc-L and activL. Eight-year data have been reported from a comparison of ProDisc II with multidisciplinary rehabilitation.

A key feature all of these trials is the recruitment of patients specifically with degenerative disease of the intervertebral disc. Degenerative disc disease is partly a diagnosis of exclusion where the degenerated disc is believed to be the pain generator. Radiographic evidence of degenerative disc disease may include a reduction of disc height and Modic changes, a posterior high-intensity zone, or a dark/black nucleus pulposus on T2-weighted images. Patients with common indications for spinal fusion such as scoliosis, spondylolisthesis, instability, or radiculopathy were excluded.

Characteristics of these trials are summarized in Table 3, results in Table 4, and study relevance, design, and conduct limitations are summarized in Tables 5 and 6.

**Lumbar Artificial Intervertebral Disc vs Fusion**

**ProDisc®-L at a Single Level**
The pivotal study for the ProDisc-L was an unblinded noninferiority trial that originally followed patients for 24 months. In the per-protocol analysis reported to FDA, ProDisc-L had a success rate of 53.4% and fusion had a success rate of 40.8%, which achieved both non-inferiority and superiority. Two-year results from this trial were published in 2007, and 5-year follow-up was reported in 2012. The definition of success was changed from the analysis requested by FDA and was reported to be higher at 63.5% at 2 years and 53.7% at 5 years. Noninferiority but not superiority of artificial disc replacement was achieved at 5 years. This change in overall success in ProDisc-L patients indicates a possible decrement in response over time with the artificial disc. This decline in response rate was not observed in the standard fusion group and resulted in a between-group convergence of the primary outcome measure over time. Several individual components of the primary outcome measure and secondary outcome measures (Oswestry Disability Index, 36-Item Short-Form Health Survey Physical Component Summary, neurologic success, device success) were also statistically better in the ProDisc-L group than in the fusion group at 2 years, but not at 5 years. Post hoc analysis of radiographs found fewer patients with adjacent-level degeneration in the ProDisc-L group than in the control group. However, the adjacent-level reoperations did not differ significantly between groups (1.9% ProDisc-L vs 4% controls).

An updated TEC Assessment (2013) evaluated 5-year follow-up from the ProDisc pivotal trial. The Assessment concluded that:

- Additional study of ProDisc in an appropriately powered clinical trial with minimum 5-year follow-up is needed to confirm the results of the investigational device exemption trial in patients with single-level chronic symptomatic degenerative disc disease unresponsive to conservative management.
- Questions remain about the durability of the disc, in particular, the long-term effects on patient health of polyethylene wear debris. Surgical revision of a failed or dysfunctional disc may be complicated and dangerous to the patient, so the lifespan of a prosthetic device is a key issue.
- The main claim of the artificial disc—that it maintains range of motion and thereby reduces the risk of adjacent-level segment degeneration better than fusion—remains subject to debate.
**ProDisc®-L at 2 Levels**
The ProDisc-L for 2-level lumbar degenerative disc disease was reported in 2011 from a multicenter, randomized, FDA regulated noninferiority trial. All patients had degenerative disc disease at 2 contiguous vertebral levels from L3 to S1 with or without leg pain, a minimum of 6 months of conservative therapy, and a minimum Oswestry Disability Index score of 40. The ProDisc-L group had faster surgeries (160.2 minutes vs 272.8 minutes), less estimated blood loss (398.1 mL vs 569.3 mL), and shorter hospital lengths of stay (3.8 days vs 5.0 days) than the arthrodesis group. The composite measure of success demonstrated noninferiority but not superiority of ProDisc-L. The ProDisc-L group showed significant benefit in the percentages of patients who achieved at least a 15-point improvement in Oswestry Disability Index scores and greater improvements in the SF-36 scores. A greater percentage of patients in the arthrodesis group required secondary surgical procedures. As noted in an accompanying commentary, the study had a number of limitations. Comparison with a procedure (open 360° fusion) that is not the criterion standard precludes decisions on the comparative efficacy of this procedure to the standard of care. Other limitations include the relatively short follow-up and lack of blinding of patients and providers.

**activL® Artificial Disc**
There are no RCTs of activL® compared to fusion.

Two-year outcomes from the multicenter investigational device exemption trial of the activL artificial intervertebral disc were reported by Garcia et al (2015). In this patient-blinded noninferiority trial, patients with degenerative disc disease were randomized to treatment with activL or an FDA approved disc (ProDisc-L or Charité). At 2 years, activL was both noninferior and superior to the control group of patients treated with ProDisc-L or Charité. Intention-to-treat analysis of secondary outcome measures showed similar improvements between activL and controls. Range of motion at the index level, measured by an independent core radiographic laboratory, was higher in the activL group than in the controls.

Five-year results from this trial were reported in Yue et al (2019). Of 341 patients enrolled, 261 contributed data at 5 years (76.5%). The primary composite endpoint results were reported graphically only, and demonstrated noninferiority at 5 years for activL versus control artificial discs. Sensitivity analyses using various imputation methods for missing data also showed noninferiority of activL, with the exception of the worst-case scenario (missing data counted as failure for activL and success for control). Freedom from serious adverse events through 5 years was 64% with activL and 47% with control artificial discs (P=0.0068).

Because this study compared activL to other fusion devices, it provides only indirect evidence of effectiveness compared to fusion or conservative care. The study was not powered to detect differences by different control devices, and the control group includes patients who received a device that is no longer available in the United States. Additional limitations were a high loss to followup at 5 years, unblinded outcome assessment, and no blinding of patients at the 5-year assessment.

**Lumbar Artificial Intervertebral Disc Versus Conservative Treatment**
There are no RCTs of activL® compared to conservative treatment.
Hellum et al (2011) reported an RCT that compared the use of the ProDisc-L with a multidisciplinary rehabilitation program. Patients (N=173) were ages 25 to 55 years, had low back pain for at least a year, received physical therapy or chiropractic treatment for at least 6 months without sufficient effect, had an Oswestry Disability Index score of at least 30, and showed degenerative intervertebral changes that included at least 40% reduction of disc height, Modic changes, a high-intensity zone in the disc, and morphologic changes identified as changes in the signal intensity in the disc of grade 3 or 4. The multidisciplinary rehabilitation included a cognitive approach and supervised physical exercise. The primary outcome was Oswestry Disability Index score, and the trial was powered to detect a 10-point difference in Oswestry Disability Index score. The analysis was intention-to-treat with the last observation carried forward. There were 13 (15%) dropouts in the surgical arm and 21 (24%) in the rehabilitation arm. Also, 5 (6%) patients crossed over from rehabilitation to surgery. Of the 34 patients lost to follow-up, 26 answered a questionnaire between 2.5 and 5 years after treatment. In the intention-to-treat analysis, there was a statistically significant benefit of surgery, but the mean difference did not achieve the 10-point difference in Oswestry Disability Index score considered clinically significant. There were significantly more patients who achieved a 15-point improvement in Oswestry Disability Index score in the ProDisc group, with a number needed to treat of 4.4. The radiographic assessment identified a similar level of adjacent segment degeneration in both groups, but an increase in facet arthropathy in the ProDisc II group.

Eight-year follow-up of this trial was reported by Furunes et al (2017). In both the intention-to-treat and per-protocol analysis there was a statistically significant benefit of surgery as measured by the mean Oswestry Disability Index, but these differences did not reach the clinically significant threshold of 10 points (see Table 4). More patients in the surgery group (43/61 [70%]) reached a clinically important difference of 15 Oswestry Disability Index points than in the rehabilitation group (26/52 [50%]; p=0.03). Twenty-one (24%) patients randomized to rehabilitation crossed over to surgery while 12 (14%) patients randomized to surgery had undergone additional back surgery.

Table 3. Summary of Key RCT Characteristics for Lumbar Artificial Discs Available in the United States

<table>
<thead>
<tr>
<th>Study</th>
<th>Publications</th>
<th>Countries</th>
<th>Sites</th>
<th>Follow-Up</th>
<th>Study Design and Participants</th>
<th>Interventions</th>
<th>Number Analyzed</th>
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<tr>
<td>ProDisc-L IDE Study</td>
<td></td>
<td>U.S.</td>
<td>17</td>
<td></td>
<td>Noninferiority trial of patients with single-level DDD</td>
<td>ProDisc-L n=161</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2 y</td>
<td>2 year results</td>
<td>n=156</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5 y</td>
<td>5-year results</td>
<td>n=137</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5 y</td>
<td>5-year adjacent level degeneration results</td>
<td>n=123</td>
</tr>
<tr>
<td>ProDiscL IDE Study NCT00295009</td>
<td>Delamarter et al (2011)</td>
<td>U.S.</td>
<td>16</td>
<td>2 y</td>
<td>Noninferiority trial of patients with DDD at 2 contiguous levels</td>
<td>ProDisc-L at 2 levels n=158</td>
<td></td>
</tr>
<tr>
<td>activL IDE Study NCT00589797</td>
<td>Garcia et al (2015)</td>
<td>U.S.</td>
<td>17</td>
<td>2 y</td>
<td>Patient-blinded noninferiority trial of patients with DDD</td>
<td>activL n=218</td>
<td>ProDisc-L or Charité n=106</td>
</tr>
<tr>
<td></td>
<td>Yue et al (2019)</td>
<td></td>
<td></td>
<td></td>
<td>5 y</td>
<td>5-y follow-up (open label)</td>
<td>n=176</td>
</tr>
<tr>
<td>Study</td>
<td>Publications</td>
<td>Countries</td>
<td>Sites</td>
<td>Follow-Up</td>
<td>Study Design and Participants</td>
<td>Interventions Number Analyzed</td>
<td></td>
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<tr>
<td>ProDisc II vs Conservative Treatment NCT00394732</td>
<td>Hellum et al (2011)¹²</td>
<td>Norway</td>
<td>5</td>
<td>2 y</td>
<td>Patients with chronic low back pain, ODI score ≥30, and DDD in 1 or 2 levels</td>
<td>ProDisc II n=87   Multidisciplinary rehabilitation n=86</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hellum et al (2012)¹³</td>
<td></td>
<td></td>
<td>2 y</td>
<td>Adjacent-level degeneration and facet arthropathy results</td>
<td>ProDisc II n=59   Multidisciplinary rehabilitation n=57</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Furunes et al (2017)¹⁴</td>
<td></td>
<td></td>
<td>8 y</td>
<td>8-y follow-up</td>
<td>ProDisc II n=77   Multidisciplinary rehabilitation n=74</td>
<td></td>
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</tbody>
</table>

IDE: Investigational Device Exemption; DDD: degenerative disc disease; ODI: Oswestry Disability Index; RCT: randomized controlled trial.

### Table 4. Summary of Key RCT Outcomes for Artificial Intervertebral Discs Available in the United States

<table>
<thead>
<tr>
<th>Study</th>
<th>Success Rate at 2 Years</th>
<th>Success Rate at 5 Years</th>
<th>ODI Score at 2 years Mean (SD)% change (SD)</th>
<th>ODI Score at 5 years Mean (SD)% change (SD)</th>
<th>VAS Score at 2 years Mean (SD)% change (SD)</th>
<th>VAS Score at 5 years Mean (SD)% change (SD)</th>
<th>SF-36 at 2 years Mean (SD)% change (SD)</th>
<th>SF-36 at 5 years Mean (SD)% change (SD)</th>
<th>Adjacent-Level Degeneration at 5 Years</th>
<th>Reoperation at 5 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zigler et al (2007, 2012)¹⁶,¹⁷,¹⁸</td>
<td>63.5%</td>
<td>53.7%</td>
<td>34.5 (24.5) - 47.4 (34.7)</td>
<td>34.2 (24.3) - 47.5 (34.7)</td>
<td>34.5 (24.5) - 47.4 (34.7)</td>
<td>43.3 (31.6) - 42.4 (42.9)</td>
<td>36.6 (30.1) - 49.9 (41.9)</td>
<td>37.1 (29.3) - 48.7 (44.6)</td>
<td>42.8 (11.1) - 39.4 (43.5)</td>
<td>42.0 (13.6) - 29.9 (43.7)</td>
</tr>
<tr>
<td></td>
<td>219</td>
<td>193</td>
<td>220</td>
<td>177</td>
<td>220</td>
<td>176</td>
<td>217</td>
<td>177</td>
<td>161</td>
<td>193</td>
</tr>
<tr>
<td>ProDisc-L</td>
<td>63.5%</td>
<td>53.7%</td>
<td>34.5 (24.5) - 47.4 (34.7)</td>
<td>34.2 (24.3) - 47.5 (34.7)</td>
<td>34.5 (24.5) - 47.4 (34.7)</td>
<td>43.3 (31.6) - 42.4 (42.9)</td>
<td>36.6 (30.1) - 49.9 (41.9)</td>
<td>37.1 (29.3) - 48.7 (44.6)</td>
<td>42.8 (11.1) - 39.4 (43.5)</td>
<td>42.0 (13.6) - 29.9 (43.7)</td>
</tr>
<tr>
<td>Fusion</td>
<td>45.1%</td>
<td>50.0%</td>
<td>39.8 (24.3) - 37.8 (36.0)</td>
<td>34.5 (24.5) - 47.4 (34.7)</td>
<td>43.3 (31.6) - 42.4 (42.9)</td>
<td>36.6 (30.1) - 49.9 (41.9)</td>
<td>37.1 (29.3) - 48.7 (44.6)</td>
<td>42.8 (11.1) - 39.4 (43.5)</td>
<td>42.0 (13.6) - 29.9 (43.7)</td>
<td>28.6% (4.0% required surgery)</td>
</tr>
<tr>
<td></td>
<td>6/137</td>
<td>4.4%</td>
<td>193</td>
<td>177</td>
<td>161</td>
<td>193</td>
<td>5/56</td>
<td>9.0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P inferiority</td>
<td>&lt;0.01</td>
<td>0.024</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P superiority</td>
<td>0.044</td>
<td>0.7438</td>
<td>0.055</td>
<td>0.455</td>
<td>0.134</td>
<td>0.567</td>
<td>0.036</td>
<td>0.168</td>
<td>0.004</td>
<td></td>
</tr>
<tr>
<td>Delamarter et al (2011)²⁰</td>
<td>58.8%</td>
<td>NR</td>
<td>52.4% (54.6)</td>
<td>NR</td>
<td>-43.3</td>
<td>NR</td>
<td>54.2%</td>
<td>NR</td>
<td>NR</td>
<td></td>
</tr>
<tr>
<td></td>
<td>203</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fusion</td>
<td>47.8%</td>
<td>NR</td>
<td>40.5% (44.9)</td>
<td>NR</td>
<td>-36.7</td>
<td>NR</td>
<td>36.2%</td>
<td>NR</td>
<td>NR</td>
<td></td>
</tr>
<tr>
<td>P noninferiority</td>
<td>0.0008</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P superiority</td>
<td>0.09</td>
<td>0.03</td>
<td>0.118</td>
<td>0.014</td>
<td>0.047</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garcia et al (2015)²¹</td>
<td>NR (graph only)</td>
<td>NR (graph only)</td>
<td>% with &gt;15 point improvement: 75.2%</td>
<td>% with &gt;15 point improvement: 82.7%</td>
<td>% with &gt;15 point improvement: 67%</td>
<td>% with &gt;15 point improvement: 74%</td>
<td>% with &gt;15 point improvement: 88%</td>
<td>% with &gt;15 point improvement: 87%</td>
<td>% with &gt;15 point improvement: 87%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>324</td>
<td>324</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>activ-L</td>
<td>NR (graph only)</td>
<td>NR (graph only)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>


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Contains Public Information
### Study Limitations

Tables 5 and 6 summarize the relevance, design, and conduct limitations of the RCTs of artificial discs available in the U.S. The most serious limitations included a lack of blinding, insufficient followup to evaluate potential harms, and comparators that are not relevant to current practice.

### Table 5. Study Relevance Limitations- RCTs of Artificial Intervertebral Discs Available in the United States

<table>
<thead>
<tr>
<th>Study</th>
<th>Population</th>
<th>Intervention</th>
<th>Comparator</th>
<th>Outcomes</th>
<th>Follow-Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>ProDisc-L IDE Study</td>
<td>173</td>
<td>51(70%)</td>
<td>31(47%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ProDisc II</td>
<td>151(8 years)</td>
<td>151(8 years)</td>
<td>151(8 years)</td>
<td>8 years</td>
<td>173(8 years)</td>
</tr>
<tr>
<td>Rehab</td>
<td>31 (47%)</td>
<td>26.7 (14.5)</td>
<td>14.4 (10.7 to 18.1)</td>
<td>49.7</td>
<td>NR</td>
</tr>
<tr>
<td>p</td>
<td>0.006</td>
<td>0.02</td>
<td>0.04</td>
<td>&lt;0.001</td>
<td>NR</td>
</tr>
<tr>
<td>NNT 4.4 (95% CI 2.6 to 14.5)</td>
<td>MD = -6.9 (-11.7 to -2.1)</td>
<td>MD = 6.1 (1.2 to 11.0)</td>
<td>MD = 9.9 (0.6-19.2)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CI: confidence interval; MD: mean difference; NNT: number needed to treat; MD: mean difference; NR: not reported; ODI: Oswestry Disability Index; RCT: randomized controlled trial; Rehab: multidisciplinary rehabilitation; VAS: visual analog score.
The evidence limitations stated in this table are those notable in the current review; this is not a comprehensive gaps assessment.

<table>
<thead>
<tr>
<th>Study</th>
<th>Population&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Intervention&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Comparator&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Outcomes&lt;sup&gt;d&lt;/sup&gt;</th>
<th>Follow-Up&lt;sup&gt;e&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yue et al (2019)</td>
<td>4. 33% of surgery patients underwent 2-level surgery</td>
<td>24% of patients randomized to rehabilitation crossed over to surgery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ProDisc II vs conservative care</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hellum et al</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The evidence limitations stated in this table are those notable in the current review; this is not a comprehensive gaps assessment.

<sup>a</sup> Population key: 1. Intended use population unclear; 2. Clinical context is unclear; 3. Study population is unclear; 4. Study population not representative of intended use.

<sup>b</sup> Intervention key: 1. Not clearly defined; 2. Version used unclear; 3. Delivery not similar intensity as comparator; 4. Not the intervention of interest.

<sup>c</sup> Comparator key: 1. Not clearly defined; 2. Not standard or optimal; 3. Delivery not similar intensity as intervention; 4. Not delivered effectively.

<sup>d</sup> Outcomes key: 1. Key health outcomes not addressed; 2. Physiologic measures, not validated surrogates; 3. No CONSORT reporting of harms; 4. Not establish and validated measurements; 5. Clinical significant difference not prespecified; 6. Clinical significant difference not supported.

<sup>e</sup> Follow-Up key: 1. Not sufficient duration for benefit; 2. Not sufficient duration for harms.

### Table 6. Study Design and Conduct Limitations- RCTs of Artificial Intervertebral Discs Available in the United States

<table>
<thead>
<tr>
<th>Study</th>
<th>Allocation&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Blinding&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Selective Reporting&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Data Completeness&lt;sup&gt;d&lt;/sup&gt;</th>
<th>Power&lt;sup&gt;e&lt;/sup&gt;</th>
<th>Statistical&lt;sup&gt;f&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>ProDisc IDE Study</td>
<td>1, 2 Not blinded</td>
<td></td>
<td></td>
<td>1. High and differential loss to followup at 5 years (25% fusion vs 15% artificial disc)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ProDisc 2-level Study</td>
<td>1, 2 Not blinded</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delamarter et al (2011)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ActivL IDE study</td>
<td>Outcome assessment not blinded, patients blinded at 2 y but not 5 y</td>
<td></td>
<td></td>
<td>1. high loss to followup at 5 years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garcia et al</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yue et al (2019)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ProDiscL vs conservative care</td>
<td>1. high and differential loss to followup</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hellum et al</td>
<td></td>
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</tbody>
</table>
Observational Studies
While observational studies do not provide evidence of efficacy or comparative efficacy, they may provide information about the durability of any observed improvements and potential impacts of patient selection factors (see Tables 7 and 8).

Siepe et al (2014) reported on a minimum 5-year follow-up for 181 patients implanted with the ProDisc II at their institution. This represented 90.0% of the initial cohort of 201 patients from this prospective clinic-funded quality review. Oswestry Disability Index and visual analog score pain scores were assessed by investigators not involved in pre- or postoperative decision making. At final follow-up, Oswestry Disability Index and visual analog score pain scores were significantly improved over baseline. Overall satisfaction rates were 89.1% for single-level and 69.0% for 2-level disc replacement.

Laugesen et al (2017) found significant improvements in pain and function with 1- or 2-level ProDisc II implantation at follow-up of 10.6 years, but pain remained moderate, and about one-third of patients required revision to fusion. The authors noted the need for appropriate selection criteria.

Another case series, by Tropiano et al (2005), followed 55 patients for an average of 8.7 years after disc replacement with the ProDisc-L; 60% of patients reported excellent results.

Table 7. Summary of Prospective Cohort Study Characteristics

<table>
<thead>
<tr>
<th>Study</th>
<th>Country</th>
<th>Participants, N (% of total treated)</th>
<th>Treatment Delivery</th>
<th>Follow-Up (Range), Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Siepe et al (2014)</td>
<td>Germany</td>
<td>181 (90%)</td>
<td>ProDisc-II at 1 or 2 levels</td>
<td>7.4 (5.0-10.8)</td>
</tr>
<tr>
<td>Laugesen et al (2017)</td>
<td>Denmark</td>
<td>57 (84%) with DDD</td>
<td>ProDisc-II at 1 or 2 levels</td>
<td>10.6 (8.1-12.6)</td>
</tr>
</tbody>
</table>

DDD: degenerative disc disease.

Table 8. Summary of Key Cohort Study Results

<table>
<thead>
<tr>
<th>Study</th>
<th>Treatment</th>
<th>Functional Status at Baseline</th>
<th>Score at FU p</th>
<th>VAS Score at Baseline</th>
<th>VAS at FU p</th>
<th>Complication Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Siepe et al (2014)</td>
<td>1 or 2 level ProDisc-II</td>
<td>42 (ODI)</td>
<td>22 &lt;0.001</td>
<td>7</td>
<td>3.3</td>
<td>11.9% 1 level 27.6% 2 levels</td>
</tr>
<tr>
<td>Laugesen et al (2017)</td>
<td>1 or 2 level ProDisc-II</td>
<td>63.2 (PDQ)</td>
<td>45.6 &lt;0.001</td>
<td>6.8</td>
<td>3.2</td>
<td>33% revised to fusion</td>
</tr>
</tbody>
</table>

FU: follow-up; ODI: Oswestry Disability Index; PDQ: Dallas Pain Questionnaire; VAS: visual analog scale.

Summary of Evidence
For individuals who have lumbar degenerative disc disease who receive a lumbar artificial intervertebral disc, the evidence includes randomized controlled trials (RCTs) of artificial discs vs fusion with 5-year outcomes and case series with longer term outcomes. Relevant outcomes are symptoms, functional outcomes, quality of life, and treatment-related morbidity. Five-year outcomes for the ProDisc®-L RCT have provided evidence for the noninferiority of artificial disc replacement compared to spinal fusion. The superiority of ProDisc®-L with circumferential fusion...
was achieved at 2 but not at 5 years in this unblinded trial. The potential benefits of the artificial disc (eg, faster recovery, reduced adjacent-level disc degeneration) have not been demonstrated. Also, considerable uncertainty remains whether response rates will continue to decline over longer time periods and long-term complications with these implants will emerge. Although some randomized trials have concluded that this technology is noninferior to spinal fusion, outcomes that would make noninferiority sufficient to demonstrate the clinical benefit of the artificial lumbar disc have not been established. No RCTs compared activL® to spinal fusion or conservative care. RCTs were limited by a lack of blinding, insufficient followup to evaluate potential harms, and lack of comparison to the criterion standard for treatment of degenerative disc disease. The evidence is insufficient to determine the effects of the technology on health outcomes.

Clinical Input From Physician Specialty Societies and Academic Medical Centers
While the various physician specialty societies and academic medical centers may collaborate with and make recommendations during this process, through the provision of appropriate reviewers, input received does not represent an endorsement or position statement by the physician specialty societies or academic medical centers, unless otherwise noted.

In response to requests, input was received from 1 physician specialty society and 3 academic medical centers while this policy was under review in 2008. The 4 reviewers disagreed with the policy statement that artificial intervertebral discs for the lumbar spine are investigational.

After considering the clinical input in 2008, it was concluded that, due to limitations of the available randomized controlled trials (described herein), combined with the marginal benefit compared with fusion, evidence was insufficient to determine whether artificial lumbar discs are beneficial in the short term. Also, serious questions remained about potential long-term complications with these implants.

Practice Guidelines and Position Statements
North American Spine Society
In 2019, the North American Spine Society issued coverage recommendations for lumbar artificial disc replacement. Lumbar Artificial Disc Replacement is indicated for patients with discogenic low back pain who meet ALL of the following criteria:

1. Symptomatic single level lumbar disc disease at L3-L4, L4-L5 or L5-S1 level
2. Presence of symptoms for at least 6 months or greater and that are not responsive to multi-modal nonoperative treatment over that period that should include a physical therapy/rehabilitation program but may also include (but not limited to) pain management, injections, cognitive behavior therapy, and active exercise programs
3. Any underlying psychiatric disorder, such as depression, should be diagnosed and the management optimized prior to surgical intervention
4. Primary complaint of axial pain, with a possible secondary complaint of lower extremity pain

Lumbar Disc Arthroplasty is NOT indicated in ANY of the following scenarios:

1. Any case that does not fulfill ALL of the above criteria
2. Presence of symptomatic degenerative disk disease at more than one level
3. Presence of spinal instability with spondylolisthesis greater than Grade I
4. Chronic radiculopathy (unremitting pain with predominance of leg pain symptoms greater than back pain symptoms extending over a period of at least one year)
5. Osteopenia as evidenced by a DEXA bone mineral density T-score less than or equal to -1.0
6. Poorly managed psychiatric disorder
7. Significant facet arthropathy at the index level
8. Age greater than 60 years or less than 18 years
9. Presence of infection or tumor

**American Pain Society**

In 2009, the American Pain Society’s practice guidelines concluded there was “insufficient evidence” to adequately evaluate the long-term benefits and harms of vertebral disc replacement. The guidelines were based on a systematic review commissioned by the Society and conducted by the Oregon Evidence-Based Practice Center. The rationale for the recommendation was that, although artificial disc replacement has been associated with outcomes similar to fusion, the trial results were only applicable to a narrowly defined subset of patients with single-level degenerative disease, and the type of fusion surgery in the trials is no longer widely used due to frequent poor outcomes. Also, all trials had been industry-funded, and data on long-term (>2 years) benefits and harms following artificial disc replacement were limited.

**National Institute for Health and Care Excellence**

In 2009, the National Institute for Health and Care Excellence updated its guidance on the safety and efficacy of prosthetic intervertebral disc replacement in the lumbar spine with studies reporting 13-year follow-up but with most of the “evidence from studies with shorter durations of follow-up.” The Institute concluded that evidence was “adequate to support the use of this procedure.”

**U.S. Preventive Services Task Force Recommendations**

Not applicable.

**Ongoing and Unpublished Clinical Trials**

A currently unpublished trial that might influence this review is shown in Table 9.

**Table 9. Summary of Key Trials**

<table>
<thead>
<tr>
<th>NCT No.</th>
<th>Trial Name</th>
<th>Planned Enrollment</th>
<th>Completion Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ongoing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NCT02381574&lt;sup&gt;a&lt;/sup&gt;</td>
<td>French Lumbar Total Disk Replacement Observational Study (FLTDR Observational Study)</td>
<td>600</td>
<td>Dec 2020</td>
</tr>
</tbody>
</table>

NCT: national clinical trial.
<sup>a</sup> Denotes industry-sponsored or cosponsored trial
CODING

The following codes for treatment and procedures applicable to this policy are included below for informational purposes. Inclusion or exclusion of a procedure, diagnosis or device code(s) does not constitute or imply member coverage or provider reimbursement. Please refer to the member's contract benefits in effect at the time of service to determine coverage or non-coverage of these services as it applies to an individual member.

CPT/HCPCS

22857  Total disc arthroplasty (artificial disc), anterior approach, including discectomy to prepare interspace (other than for decompression), single interspace, lumbar

22862  Revision including replacement of total disc arthroplasty (artificial disc), anterior approach, single interspace, lumbar

22865  Removal of total disc arthroplasty (artificial disc), anterior approach, single interspace, lumbar

0163T  Total disc arthroplasty (artificial disc), anterior approach, including discectomy to prepare interspace (other than for decompression), each additional interspace, lumbar (List separately in addition to code for primary procedure)

0164T  Removal of total disc arthroplasty (artificial disc), anterior approach, each additional interspace, lumbar (List separately in addition to code for primary procedure)

0165T  Revision including replacement of total disc arthroplasty (artificial disc), anterior approach, each additional interspace, lumbar (List separately in addition to code for primary procedure)

DIAGNOSIS

Experimental / investigational for all diagnoses related to this medical policy.

REVISIONS

<table>
<thead>
<tr>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
</table>
| 09-23-2008 | In Description section:  
  ▪ Updated wording  
  In Policy section:  
  ▪ Removed "Removal or revision of artificial disc(s) is a non-covered service."  
  In Coding section:  
  ▪ Removed CPT codes 0090T, 0092T, 0093T, 0095T, 0096T, 0098T  
  Added Rationale section |
| 02-22-2010 | Updated wording for CPT codes: 22857, 22862, 22865, 0163T, 0164T, 0165T  
  Rationale and References updated. |
| 03-10-2011 | Description section updated  
  Rationale section updated  
  References updated |
| 03-08-2013 | Description section updated  
  Rationale section updated  
  In Coding section:  
  ▪ Coding notations updated.  
  References updated |
| 06-23-2015 | Description section update  
  Rationale section updated |
REFERENCES


10. Schoenfeld AJ. Commentary on an article by Rick Delamarter, MD, et al.: "Prospective, randomized, multicenter Food and Drug Administration investigational device exemption study of the ProDisc-L..."
total disc replacement compared with circumferential arthrodesis for the treatment of two-level degenerative lumbar disc disease. Results at twenty-four months". J Bone Joint Surg Am. Apr 20