



# CIGNA MEDICAL COVERAGE POLICY

The following Coverage Policy applies to all plans administered by CIGNA Companies including plans administered by Great-West Healthcare, which is now a part of CIGNA.

Subject **Intervertebral Disc (IVD)  
Prostheses**

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## Coverage Policy

**CIGNA covers the surgical implantation of the Charité® or ProDisc®-L lumbar intervertebral disc (IVD) prosthesis for chronic, unremitting, discogenic low back pain and disability secondary to single-level degenerative disc disease (DDD) as medically necessary in a skeletally mature individual when ALL of the following criteria are met:**

- The unremitting low back pain and disability described has been refractory to at least six consecutive months of standard medical and surgical management (e.g., exercise, analgesics, physical therapy, spinal education).
- Single-level disc degeneration has been confirmed on complex imaging studies (i.e., computerized tomography [CT] scan, magnetic resonance imaging [MRI]).
- The planned implant will be used in the L4–S1 region if Charité or the L3-S1 region if ProDisc®-L.

**CIGNA does not cover the surgical implantation of any of the following because they are considered experimental, investigational or unproven:**

- A Charité or ProDisc®-L lumbar intervertebral disc prosthesis when any of the following apply:
  - The planned procedure includes the combined use of a prosthesis and spinal fusion.

- Simultaneous multilevel implantation is planned.
- The implant will be inserted outside of the L4–S1 region (Charité) or outside of the L3–S1 region (ProDisc®-L).
- The individual has osteopenia or osteoporosis (T-score < -1.0).
- The individual has a history of prior lumbar fusion.
- There is evidence on imaging studies of ANY of the following:
  - degenerative spondylolisthesis of Grade 2 or greater
  - infection
  - multilevel degenerative disc disease
  - nerve root compression or spinal stenosis
  - pars interarticularis defect with either spondylolysis or isthmic spondylolisthesis
  - scoliosis
  - severe facet joint arthrosis
  - spinal fracture
  - tumor
- A lumbar disc prosthesis other than Charité or ProDisc®-L

**CIGNA does not cover the implantation of the cervical intervertebral disc prosthesis (e.g., PRESTIGE™ ST, ProDisc™-C, BRYAN® Cervical Disc) for any indication because it is considered experimental, investigational or unproven.**

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## General Background

Degenerative disc disease (DDD) is considered by some to be a normal part of the aging process. Clinical symptoms are consistent with mechanical back pain, which is aggravated by activity and relieved by rest. Standard therapy for individuals not exhibiting neurological deficits (i.e., rapidly progressive motor or sensory deficit or cauda equina) typically involves a period of conservative treatment, consisting of nonsteroidal anti-inflammatory drugs (NSAIDs), physical therapy, ice or heat. Diagnostic studies conducted to confirm the actual location of the herniation can include myelography, electrodiagnosis, discography, computed tomography (CT) scanning with and without contrast, magnetic resonance imaging (MRI) with and without contrast, and bone scintigraphy.

Spinal fusion with or without instrumentation (e.g., Bagby and Kuslich [BAK] cages, screws) may be sought if conservative treatment fails and is considered the standard surgical treatment for DDD. Complications following spinal fusion are reported in approximately 10% of all cases, including nonunion, loss of spinal curvature and flexibility. Spinal fusion alters the biomechanics of the spine, reducing motion of the spinal segments, potentially leading to premature disc degeneration at adjacent levels.

Preservation of motion within the spinal column and avoidance of adjacent segment disease are goals for treatment of patients with degenerative disc disease (DDD) or other painful spine conditions. Due to the limitations and complications associated with spinal fusion, researchers have developed intervertebral disc prostheses (IVD) as an alternative surgical option. These prostheses replace the degenerated disc and have been proposed as a means of improving flexibility, maintaining spinal curvature and providing an equalized weight-bearing surface, while reducing or possibly eliminating back pain.

### Lumbar Intervertebral Disc Prostheses

There are two lumbar intervertebral disc prostheses that have been approved by the U.S. Food and Drug Administration (FDA) for surgical implantation within the spine for single-level disc replacement: The Charité® Artificial Disc (DePuy Spine, Inc., Raynham, MA) and the ProDisc®-L Lumbar (SYNTHES Spine, Inc., West Chester, PA).

**Charité:** The Charité lumbar prosthesis was initially developed in 1984 and has been modified several times, with the latest modification being called the SB Charité III. The device consists of two cobalt chromium alloy endplates and a polyethylene sliding core.

**U.S. Food and Drug Administration (FDA):** In October 2004, the FDA granted a premarket approval (PMA) for the Charité Artificial Disc. This device is approved for patients who are skeletally mature with DDD at one level from L4–S1 with no more than three millimeters (mm) of spondylolisthesis at the involved level; the patient should have failed at least six months of conservative nonsurgical treatment prior to implantation of the device.

The FDA defined DDD as discogenic back pain with degeneration of the disc confirmed by patient history and radiographic studies (i.e., patient selection criteria for these studies included magnetic resonance imaging [MRI] or computerized tomography [CT] in conjunction with a discogram that mapped the specific anatomic location of the DDD as well as demonstrated concordant pain reproduction).

FDA approval was based on a review of a clinical study of safety and effectiveness conducted by DePuy at six medical centers (Geisler, et al., 2004, [see below]). Upon approval of the device, the FDA required the manufacturer to conduct a post-approval study to determine the long-term safety and effectiveness of the IVD device. The FDA required the patients to be evaluated for a total of five years post-implantation and identified endpoints for determining overall success.

In addition, the FDA is requiring annual reports regarding all subjects enrolled in the post-approval study measuring: overall success; surgical interventions at the index or adjacent levels; pain (i.e., measured at rest using visual analog scales [VAS]); quality of life using SF-36; disc height; displacement of the device; incidence of radiolucency; correlation of range of motion with VAS scores, ODI scores, and overall success; evaluation of adjacent segment degeneration; and neurological status (FDA, 2004).

According to the FDA, the Charité device is contraindicated in patients with the following conditions:

- active systemic infection or infection localized to the site of implantation
- osteoporosis
- osteopenia
- bony lumbar stenosis
- allergy or sensitivity to implant materials
- isolated radicular compression syndromes, especially due to disc herniation
- pars defect

**Literature Review—SB Charité III:** Early evidence supporting the use of this device is primarily in the form of case series, retrospective case reviews and observational studies (Griffith, et al., 1994; Cinotti, et al., 1996; LeMarie, et al., 1997; Zeegers, et al., 1999; Van Ooij, et al., 2003, 2007; DeKleuver, et al., 2003). The studies have generally been small in sample size, evaluate the use of various models of the device and include heterogeneous patient populations. Throughout these published studies the device was implanted for both single and multilevel disease. Improvements in radicular and back pain have been reported; however there is concern regarding rates of implant migration and other complications, in addition to the need for reoperation. In general, the reported outcomes of these initial studies are short-term (2 to 4 years).

Additional published studies in the medical literature continue to support safety and efficacy of the device for the proposed indications. As part of the investigational device exemption (IDE) studies, authors of randomized controlled trials demonstrated promising results (Geisler, et al., 2004; Blumenthal, et al., 2005; McAfee, et al., 2005). In 2005 one group of authors conducted a comparative retrospective study (n=17) evaluating axial rotation among subjects who had received a disc prosthesis at the L4–L5 level; 12 of these patients had also received prosthesis at the L5–S1 level. The authors noted that patients who had received disc replacements at two levels showed increased flexion. For patients with discopathy at one level, the prosthesis appeared promising; however, the role of the psoas muscle in the control of intervertebral rotation required further analysis (SariAli, et al., 2005). Later in 2006 Putzier et al. evaluated the long-term clinical and radiological results of the Charité TDR in the surgical treatment of DDD of the lumbar spine (n=53) in a retrospective review. The analysis focused on three versions of the device and their use from 1984–1989 at spinal levels ranging from L3–S1. Twelve (23%) patients underwent spinal fusions following TDR as a result of implant failure or pain; nine patients showed no signs of heterotrophic ossification or ankylosis. The remaining 32 patients (60%) showed definitive signs of ossifications resulting in spontaneous ankylosis, and nine patients (17%) showed significant degenerative changes.

Upon completion of the randomized portion of the FDA-regulated Charité IDE trial, the FDA allowed a “continued access” arm of the study to continue. After two years of the five-year mandated patient follow-up required by the FDA, McAfee and colleagues (2006) conducted an analysis of the reasons for and the success rate of revising the Charité prosthesis within this entire study population. Of the 589 patients (71 nonrandomized, 205 randomized and 313 continued access) who underwent TDR, 52 (8.8%) required secondary revisions at the index level. Within the control group of 99 BAK procedures, 10 (9.9%) required revisions. According to the authors there was no significant difference between the two groups with respect to the rate of revisions ( $p=0.7041$ ). Following the surgery, five patients in the control group developed objective neurological deficits with pseudoarthrosis, and 14 patients in the TDR group had iatrogenic neurological complications. The differences between these two groups were not statistically significant. Eight additional TDR patients required supplemental posterior decompression without instrumentation. The researchers concluded that these repeat surgeries were caused by “either incorrect patient indications or inadequate restoration of disc space height and indirectly, inadequate restoration of the foraminal height.” Sixteen patients developed new onset of leg pain that lateralized to the left side; three had pain that lateralized to the right, demonstrating a statistically significant difference ( $p=0.0029$ ). There were seven patients whose postoperative pain did not generalize specifically to either side. Five patients with pars defects found after the surgical placement of the TDR should not have been included in the clinical trial. McAfee and colleagues concluded that lumbar TDR did not preclude additional surgery at the primary site with replacements being revisable to a new motion-preserving prosthesis, ALIF and/or posterior instrumentation.

A retrospective chart and radiographic review was conducted by David (2007) of 106 patients who received an arthroplasty with the Charité SB III prosthesis from 1989–1995. These patients received single-level implants at L3–4, L4–5 and L5–S1 levels. Outcomes for these patients were measured using a modified Stauffer-Coventry classification. This classification system is no longer used, as it has been replaced by the Oswestry Disability Index, Visual Analog Scales and the SF-36 questionnaires; therefore, there was no baseline data for the author to compare outcomes. Radiographic outcomes at 10+ years were included for this study; with greater motion noted in the L4–5 than the L5–S1 segments, 96 prostheses were still mobile at a minimum of 10 years, and the overall index-level reoperation rate was 10.4%. Reoperation was due to core subluxation, core failure, post-facet arthrosis, adjacent level disease, and subsidence with subsequent axial back pain. The author concluded that in the patients with multiple previous index level procedures, only seven achieved a good to excellent result, and 86 of the 96 patients working prior to surgery had returned to work.

Five year prospective follow-up results to the multicenter Charité IDE randomized controlled trial comparing arthroplasty to arthrodesis was published in September 2008 (Guyer, et al. 2008a). A total of 160 patients completed the five year study (27 nonrandomized training cases and 133 randomized cases [90 Charité and 43 BAK cases]). Clinical evaluations were completed preoperatively, and at six weeks, three, six, 12, 24, and 60 months after surgery utilizing ODI, VAS scores, SF-36, neurological status and work status evaluations. Results were presented on an “intent-to-treat” basis rather than “as treated”; patients who crossed over to a different treatment group were maintained in the “intended-to-treat” group. The results included an improvement in ODI scores, a decrease in VAS scores, and improvements in SF-36 scores. Device success rates favored the Charité group as well as return to work status. Mean ROM at the index level also favored the Charité group. Overall, the results of the five year study are consistent with the two year reports of noninferiority of the Charité device versus ALIF with BAK cages and iliac autograft.

The effect of age and prior surgery on TDR clinical outcomes has also been reported on in the literature. Guyer, et al. (2008) studied the effect of age on clinical outcome within the patient population included in the Charité IDE trial. In a comparative trial the authors evaluated clinical outcomes for patients  $\leq$  age 45 years compared with those  $>$  age 45 years who had implantation of the Charité device. TDR was effective in correcting pain and disability in both groups, ROM was similar across groups and there were no differences across groups for complications and adverse events.

In 2008 Geisler and colleagues analyzed the clinical outcomes of patients from the Charité IDE trial with or without prior back surgery at the index level. Comparison of clinical outcomes between prior surgery and no prior surgery patients were performed using ODI and VAS scores preoperatively, and at six weeks, three, six, 12 and 24 months. At 24 months the authors also analyzed patient satisfaction and return-to-work status. The patients were subdivided into groups of those that received Charité alone (nonrandomized and randomized),

Charité training (included patients who received Charité randomized against patients with BAK devices) and control patients with BAK devices. Further subdivisions of patients within all groups included those who did and did not have prior surgery. At all subsequent time points no differences were noted in ODI scores between prior surgery and no prior surgery patients for all groups. At subsequent follow-up evaluations there was no difference in VAS score observed between prior surgery and no prior surgery patients in all groups. The authors noted no statistical difference between groups regarding rate of reoperation and adverse events. The study results demonstrated that TDR was effective in correcting pain and disability in both patient groups (prior surgery and no prior surgery) with similar outcomes from three months to two years postoperatively (Geisler, et al., 2008). ROM has also been studied and reported on in the recent literature. Cunningham et al. (2008) studied biomechanical data; in vitro ROM results were compared with in vivo two year postoperative radiography ROM evaluations. The authors reported that single-level disc replacement replicated the normal distribution of motion of the intact spine at the implanted and adjacent levels, confirming prior in vitro results (Cunningham, et al. 2008).

**Charité Device Revision/Removal:** Evidence evaluating device revision or removal consists of case reports (Kurtz, et al., 2005) and case series (Wagner, et al., 2005; Kurtz, et al, 2007; Punt, et al., 2008). Kurtz et al. (2005) noted transverse cracks on a device and evidence of oxidation; the oxidation may have been the result of permeability of the manufacturers packaging. Wagner et al. (2006) reported their surgical experience with removal of the device (n=19). Access-related complications included iliac vein injury, temporary retrograde ejaculation, small-bowel obstruction requiring lysis, and symptomatic, large retroperitoneal lymphocele. The researchers concluded that due to vascular and ureteral fixation, anterior exposure of the lumbar spine for revision or explantation of the Charité disc replacement should be performed through an alternative approach, unless the procedure is performed at less than or equal to two weeks from the original surgery. After evaluating an additional 21 Charité prostheses, Kurtz and colleagues (2007) reported rim damage including cracking, fractures, and plastic deformation. Based on their analysis, the authors strongly recommended additional research to understand the role of polyethylene wear and long-term failure mechanisms.

Punt et al. (2008) analyzed late complications after insertion of lumbar disc prostheses and described salvage operations for the same group of patients. During the last ten years, 75 patients treated with the SB III Charité disc prosthesis were followed for persistent back and leg pain. Forty-six of the 75 patients required one or more salvage operations. Reasons for reoperations included absence of pain relief; new pathology according to radiography, CT scan, or MRI; facet joint arthrosis; or migration of the prosthesis. The mean interval between insertion and retrieval of the disc prosthesis was eight years and 11 months. A total of 15 patients received posterior fusion without disc removal. Twenty-two patients had the prosthesis removed and an anterior and posterior fusion performed. Seven patients received posterior fusion elsewhere and two patients had the disc removed elsewhere. Late complications after disc implantation included 39 patients with subsidence of the disc prosthesis and 36 patients with signs of adjacent segment degeneration, narrowing of the disc and osteophytes on conventional X-rays. Eleven patients with multilevel adjacent disc degeneration developed degenerative lumbar scoliosis. In 25 patients facet joint degeneration was seen on CT-scans. In six patients posterior migration of the disc prosthesis occurred. In ten patients the authors discovered breakage of the metal wire around the core. One year preliminary follow-up data is available for ten patients; the mean VAS score before posterior fusion was 8.0 and after fusion the score was 6.3. Fourteen patients had a follow-up of more than one year; for this group the VAS score decreased significantly from 8.0 before disc prosthesis removal to 5.6 after removal ( $P < 0.05$ ). The mean Oswestry score decreased in the posterior fusion group from 57.0 to 44.6 and in the disc removal group from 56.3 to 43.0. According to the IDE criteria requiring  $\geq 25\%$  improvement, 3 out of 10 patients in the fusion group and 6 out of 13 patients in the disc removal group were clinically improved.

**ProDisc®-L:** The second IVD device that has been proposed for use in the lumbar spine for the treatment of DDD is the ProDisc®-L. The ProDisc®-L Total Disc Replacement (Synthes Spine, Inc., West Chester, PA) is a weight-bearing modular implant consisting of two endplates and one polyethylene inlay. The endplates (i.e., one inferior and one superior) are manufactured from cobalt-chromium alloy, with the superior endplate available in two sizes (i.e., medium and large) and two lordotic angles (i.e., 6 and 11 degrees). The polyethylene inlay snap-locks into the inferior endplate of the inferior convex-bearing surface that articulates with the concave-bearing surface of the superior endplate. According to the manufacturer, the ProDisc®-L (previously known as the ProDisc II) allows a range of 13 degrees of flexion and 7 degrees of extension, with lateral bending of  $\pm 10$  and axial rotation of  $\pm 3$ .

**U.S. Food and Drug Administration (FDA):** The ProDisc-L was approved on August 14, 2006, under the FDA's premarket approval (PMA) process and is indicated for spinal arthroplasty in skeletally mature patients with DDD at one level of the lumbar spine from L3–S1. Other patient selection criteria include no more than a Grade 1 spondylolisthesis at the involved level and no relief from pain after at least six months of nonsurgical treatment (FDA, 2006).

In addition to the contraindications listed for the Charité disc, contraindications for the ProDisc-L include:

- involved vertebral endplate smaller than 34.5 in the medial lateral view and/or 27 in the anterior-posterior view
- Clinically compromised vertebral bodies at affected level due to current or past trauma
- Lytic spondylolisthesis or degenerative spondylolisthesis of grade >1

The FDA has also mandated a five-year post-approval study to be conducted that will evaluate the long-term safety and effectiveness of the ProDisc-L. The FDA has provided guidance on acceptable overall success parameters, and radiological parameters that will be required in the investigational arm and the control group during this post-approval study. The FDA will also require ODI, ROM with VAS scores, and evaluation of adjacent segmental degeneration. All adverse events are to be reported, including those that occur within the continued access subjects who participated in the IDE study (FDA, 2006).

**Literature Review—ProDisc®-L:** As part of the IDE study, outcomes from a multicenter, prospective randomized controlled clinical trial of 292 patients (162 randomized, 50 nonrandomized, and 80 control subjects) were submitted to the FDA as part of the IDE study. The control group was treated for DDD at a single level between L3 to S1 using a circumferential fusion technique (i.e., interbody fusion with femoral ring allograft, posterolateral fusion with autogenous iliac crest bone graft, combined with pedicle screw instrumentation). The randomized patients received implantations of the ProDisc-L via an anterior surgical approach, with no additional instrumentation being used to secure the device placement.

During this study, the FDA requested that the data be analyzed and reported using the following criteria:

- improvement in the ODI score  $\geq 15$  points at 24 months compared to the score at baseline
- maintenance or improvement of ROM defined as (24-month flexion/extension ROM, Pre-operative flexion/extension ROM)  $\geq 0$  (with  $\pm 3^\circ$  measurement error applied)
- a non-inferiority margin of 10%

The outcomes from this study led to the FDA's PMA decision based on the severity and number of adverse events that were no worse than the control group and the overall success rate of the ProDisc that was no worse than the overall success rate of the control group; a non-inferiority margin of 10% (FDA, 2006; Zigler, 2007).

Several other well-designed studies, some including patients from the FDA IDE trial, support safety and efficacy of ProDisc-L (Delamarter et al., 2003; 2005; Leivseth, et al., 2006; Bertagnoli, et al., 2005, 2006a, 2006b; Siepe, et al., 2006; Chung, et al., 2006). Delamarter et al. (2003) reported results at 18-24 months indicating fusion patients reported a decrease in pain and functional status within the first six months, which was comparable to the scores obtained from the ProDisc implant group. At 24 months follow-up, Leivseth et al. (2006) documented the rotational and translational ROM at the level of implant versus adjacent levels of the spine. The ROMs obtained from this study group were compared to ROM norms that had been published within the literature. The authors found that sagittal plane rotational ROM of lumbar segments with ProDisc implants was low compared to the norm. When the researchers compared the ROM of the treated levels to the ROM of adjacent levels, they found these measures to be low as well. Thus, the researchers concluded that prospective studies are required to show whether the ROM of instrumented and untreated segments depends on prosthesis design, patient selection, or surgical technique and whether postoperative physical therapy could restore a normal ROM at least at the untreated levels of the spine.

Bertagnoli and colleagues evaluated ProDisc arthroplasty in several studies (2005, 2006a, 2006b). In 2005 the authors reported the results of prospective data collected from 104 subjects who underwent single-level ARD for DDD. By three months post surgery there was a decrease in ODI scores and individual pain scores. The results of this study show a 96% rate of satisfaction as reported by the patients at two years. In 2006 Bertagnoli and associates evaluated the efficacy of ProDisc arthroplasty in patients with symptomatic adjacent-segment degeneration following remote lumbar fusion (n=20). In this group of subjects at 24 month follow-up, ODI scores

significantly improved although individual pain scores did not. The authors noted long term studies were needed to determine feasibility of artificial disc replacement for adjacent segment degeneration. The results of a case series was published by this group of authors (2006b) evaluating the healing effects of smoking in subjects who received ProDisc lumbar artificial disc replacement (n=110). In this study the authors noted the intervention of disc arthroplasty was not confounded by smoking.

Three-year clinical results of ProDisc insertion for different indications were reported by Siepe et al. in 2006 (n=92). Average follow-up was 34.2 months and was subdivided into three distinct diagnostic groups in order to compare their subjective, VAS and ODI findings. Group 1 (n=40) was categorized as having DDD without additional pathology and served as the control group during this study. Group 2 (n=12) had DDD with nucleus pulposus prolapse (NPP); group 3 (n=17) had previously undergone discectomy procedures, and group 4 (n=23) had DDD with modic changes. The combined group analysis, as determined by an independent investigator, showed highly significant postoperative improvement for VAS and ODI in all groups; however, postoperative differences between groups 1, 3 and 4 were not statistically significant. Group 2 appeared to achieve and maintain the best subjective and objective results, at a mean follow-up of 33.1 months. Complication rate was 19.6%, requiring revision surgery at the index level in 8.7% of the patients and another 2.2% at the non-index level. These occurrences were considerably higher for bisegmental disc replacements (n=5 of 14 operations; 35.7%) compared with monosegmental interventions (n=11 of 77; 14.3%). The researchers concluded:

- monosegmental symptomatic DDD with or without modic changes can be regarded as an acceptable indication for TDR
- previous discectomy did not have a negative impact on outcomes, if the smallest height of prosthesis was used
- patients with DDD and large, contained, soft disc herniations with predominant low back pain are candidates for TDR
- bisegmental and multisegmental implantations were associated with a considerably higher complication rate; therefore, these should be applied carefully
- three-dimensional CT reconstruction of the prevertebral vessels should be obtained for all TDRs planned for levels L4–L5 and above before surgery
- patient selection must be precisely determined
- longer follow-up evaluations are needed to determine the real benefits of TDR for patients

The two-year outcomes from a prospective study of 38 consecutive patients who received ProDisc II prosthetic implants were reported by Chung et al. (2006). Two patients were lost to follow-up and excluded from this review. Twenty-five patients underwent single-level TDR, and 11 underwent a double-level TDR, surgical levels varied but included L5–S1, L4–L5, and L3–L4. No mechanical complications occurred during this study. Surgical complications included major vein injury (n=2) that required repair, and increased radicular pain (n=3) that resolved by six weeks with medications and epidural injections. Better clinical outcomes were noted in the patients who received a single-level disc replacement (i.e., ODI score improved > 75%), and a higher postoperative segmental ROM improved from 9.7 to 12.7 at two years. According to the researchers, study limitations included small cohort, absence of a control group (i.e., conservative or fusion treatment), and short-term follow-up.

Leahy et al. (2008) conducted a study to assess whether prior posterior lumbar surgery resulted in conditions that made disc replacement less favorable (e.g., scar tissue, destabilization). In a comparative trial, this group of authors evaluated the outcome of TDR performed in patients who had prior discectomy and pain at the involved disc level, comparing outcomes to a group of patients who did not have prior discectomy. Data was obtained from one center participating in the IDE trial for ProDisc and included only patients who reached the 24 month follow-up period. The authors reported on 20 patients who had TDR and prior lumbar discectomy and 67 who had total disc replacement and did not have prior discectomy. Outcome measures included VAS scores, an Oswestry questionnaire and assessment of postoperative patient satisfaction. No differences were found between groups at any of the defined follow-up periods (six weeks, three, six, 12, 18 and 24 months). Based on VAS and Oswestry scores both groups improved significantly. The outcome of total disc replacement was not compromised by previous discectomy; clinical results of patients who did not have prior discectomy were similar to those who did have prior discectomy.

Park et al. (2008) reported on the results of a retrospective trial (n=46, 32 which completed the trial) evaluating radiologic changes in the discs at the adjacent levels and facets after disc replacement using the ProDisc II device. Mean follow-up was 32.2 months. Outcome measures included VAS scores, ODI scores, and imaging examinations which were obtained prior to surgery and at final follow-up. Changes in disc height and flexion/extension motion were assessed at affected and adjacent levels. Single-level disc replacement was performed in 23 cases and two-level disc replacement was performed in nine cases. The progression of disc degeneration was defined as an increase in the degeneration grade of the discs after replacement and was noted in 4.3% of the adjacent discs. Progression of facet arthrosis was defined as an increase in the degeneration grade of the facet joint after replacement and was reported in nine patients at the index levels. With a total of 41 segments operated on, facet degeneration was noted in 12 segments. Among 47 adjacent segments, facet arthrosis was noted in 6.4%. All cases of facet arthrosis occurred in those with preoperative degeneration of Grade I. In the author's opinion degeneration changes in the discs and facets were minimal at adjacent segments. However, the progression of facet arthrosis at the index level was 29.3%. Additionally, the authors noted facet arthrosis was positively associated with women gender, with two-level disease and when the device was placed off of midline on the frontal plane.

Yaszay et al. (2008) reported the results of a retrospective study (n=42) evaluating the effect of preoperative disc height on postoperative motion using ODI scores and VAS scores. All patients included in this study had single-level disc replacement and participated in the FDA IDE study for ProDisc-L. Mean follow-up was 25 months. Eighteen patients had disc replacement at level L4–L5 and 24 patients had replacement at level L5–S1. At an average follow-up of 25 months, the mean anterior disc height significantly increased from 10.8 mm to 17.6 mm and posterior disc height had an increase from 4.4 mm to 7.9 mm. Mean ROM for all patients decreased from 7.0° to 5.7°. Discs with greater collapse (i.e., < 9mm preoperative anterior disc height) had an average of 2.2° gain in ROM for the disc level replaced, compared to a loss of 2.2° for those discs that were > 9mm before surgery. Similar results were demonstrated with posterior disc height. The authors noted that patients with greater loss in disc height may have had a greater degree of disc degeneration (the difference in degeneration was not classified among groups). Postoperative disc height also influenced ROM. A range of anterior disc height between 16 mm and 18 mm resulted in greater flexion and extension and patients with above or below these levels had less postoperative motion. Disc height did not correlate with either preoperative or postoperative ODI or VAS scores. Preoperative and postoperative disc height did influence ROM after disc replacement although it did not affect clinical outcomes at two years follow-up.

Siepe et al. (2008) studied postoperative pain patterns in patients who received total disc replacement with ProDisc II using fluoroscopically guided spine infiltrations to determine the source and incidence of complaints. At a mean follow-up of 29.3 months, a total of 58 patients (out of 175) had 342 infiltrations performed as part of a semi-invasive diagnostic and conservative treatment program. Facet joint pain, primarily at the index level, was identified in 22 patients. Sacroiliac joint pain was identified in 21 patients. The level of disc replacement influenced postoperative outcome with best results being achieved for patients whose disc replacement was above the L4–L5 level. Patients who received L5–S1 disc replacement or bisegmental disc replacement experienced inferior outcome and significantly higher incidence of posterior joint pain.

**Literature Review—Comparative Device Studies Lumbar:** Freeman and Davenport (2006) conducted a systematic review of the current evidence for total disc replacement using the Charité or ProDisc devices. Their search produced two randomized trials, two systematic reviews, seven prospective cohort studies, eleven retrospective cohort studies and eight case series. The level of evidence that was assigned to these studies was in accordance with the Center for Evidence Based Medicine, Oxford, UK. The authors concluded that the long-term benefits of TDR in preventing adjacent disc degeneration is unknown; the role of two- or multi-level TDR remains unproven; the role of arthroplasty adjacent to a TDR is unproven; the complications of TDR may not be known for many years; and well-designed prospective RCTs are needed.

Shim and colleagues (2007) published the results of a retrospective study evaluating and comparing radiologic outcomes of the Charité and ProDisc devices among a total of 61 patients who underwent TDR. The Charité was used in 33 patients, and ProDisc was used in 24. Degradation of disc degeneration was found at the adjacent level above the index surgical site in 19.4% of the Charité implants and 28.6% of the ProDisc implants. The authors did not find this difference to be statistically significant. They concluded that, while the clinical outcomes were fairly good, the facet joint of the index level and the disc at the adjacent level showed an aggravation of the degenerative process in a significant number of patients, regardless of the device used.

**Literature Review—Multilevel versus Single-Level Lumbar:** Increased segmental instability, increased load and altered stress distribution following total disc replacement remains a concern among authors. The FDA approved disc replacement prostheses are approved for single-level replacement. Total disc replacement for multisegmental DDD is currently considered an off-label indication for disc replacement and studies comparing the clinical outcomes of single-level disc replacement with disc replacement performed at more than one level are limited.

Hannibal and colleagues (2007) compared the clinical effect of single-level ProDisc (n=27) versus two-level ProDisc replacement (n=32) at a minimum of two years follow-up. The data analysis was obtained from two FDA IDE clinical trials. There was a reported decrease in the overall averages of VAS scores: 47% for single-level versus 37% for two-level replacement at two-year follow-up. Single-level showed a slight reduction in pain on the VAS compared to two-level but the difference was not statistically significant at 12 months or two years. There was also a decrease in ODI scores for both single and two-level replacement, 38% and 28% respectively at two years follow-up. Single-level disc replacement performed better, but not significantly better at either one- or two-year follow-up. Two level procedures resulted in increased operative time, blood loss and hospital stay compared to single level. One and two-level scores were not significantly different in any of the evaluation measures; there was no significant difference shown by the authors in single-level or two-level disc replacement in this cohort. The authors concluded that further long-term studies are needed to support recommendations for multilevel disc replacement.

The results of a prospective nonrandomized study evaluating the clinical results of disc replacement with ProDisc II performed at different lumbar motion segments was published by Siepe et al. (2007). Total disc replacement was performed in 218 patients for single-level, bi-level and multi-level DDD. A total of 99 patients met inclusion criteria which consisted of diagnosis limited to DDD without accompanying pathologies. Patients with transitional vertebrae were not included. Minimum follow-up was 12 months, average 25.8 months. The study groups were defined as follows: Group A (single-level L4–L5, n=22), Group B (single-level L5–S1, n=57) and Group C (bi-level L4–L5, L5–S1, n=20). Clinical outcome measures included VAS scores, ODI scores, and various clinical and radiograph parameters. All groups achieved highly significant improvements for VAS and ODI scores throughout the entire follow-up. Best results and the most pronounced postoperative VAS and ODI improvement however was reported for disc replacement performed at L4–L5 (Group- A). When comparing single-level replacement (L4–L5 scores to L5–S1), VAS and ODI for L5–S1 patients deteriorated, with a trend toward statistical significance at 24 months follow-up (p=0.07). A further decline was noted when disc replacement was performed bisegmentally. When comparing single-level to bi-level replacement, VAS and ODI scores for single-level replacement demonstrated superior results (p< 0.05). In addition, patients who had single-level replacement showed a more rapid postoperative recovery at both the three and six month follow-up. A comparison between Group A (L4–L5) and Group C (L4–L5, L5–S1) favored L4–L5 replacement for both VAS and ODI scores from the six month follow-up exam forward. Bi-level replacement showed deteriorating postoperative results for both ODI and VAS scores from six months to 12 months. At the time of last follow-up 77.2% of Group A patients returned to work, whereas for Group B 67.8% returned to work and 50% returned to work in the bi-level group. Complication rates for Group A, B and C was 18.2%, 12.3% and 30.0%, respectively. The revision surgery rate increased from 7% following L5–S1 replacement to 20% following bi-level replacement. Fluoroscopically guided spine infiltrations revealed the incidence of postoperative pain was 9.1% for Group A, 28.1% for Group B and 60.0% for Group C.

Zindrick et al (2008) published an evidence based medicine review for determining factors that may affect the outcome of lumbar disc replacement. The authors reviewed patient selection issues, surgical technique issues, and motion technology issues. In particular, when reviewing the patient selection issues, the authors reviewed studies regarding the outcomes of single versus multisegmental implantation. Ten case series without comparison groups were available; two were retrospective reviews and the remaining eight were prospective in design. The follow-up periods ranged from one year (two studies) to greater than 10 years (one study) with most studies averaging two year follow-up. Sample populations were small with the number of patients who received single-level replacement ranging from 106 to 25 and the number of patients receiving ≥ two-level replacement ranging from three to 45. Three studies reported inferior results while seven studies reported no differences. When reviewing evidence to determine how spinal level, a patient's age, and prior surgery affect patient selection outcomes, study design and overall conclusions were similar. The available evidence for surgical technique issues and motion preservation also consisted mainly of case series with only a limited number of higher level studies. The authors concluded that overall, the existing evidence does not provide strong conclusions regarding factors that affect clinical outcomes.

DiSilvestre et al. (2009) published the outcomes of a retrospective clinical trial evaluating patients who received bisegmental disc replacement for DDD, comparing results to single level treatment using the same disc device (Charité). A total of 32 patients with at least three year follow-up participated in the study, 16 received two level disc replacement and 16 received single level disc replacement. Radiograph, functional analysis (VAS, ODI, SF-36 scores) and patient satisfaction were evaluated following surgery. There were no signs of degenerative adjacent segment changes, and no statistically significant difference in functional outcomes at three year follow-up. It was reported that more complications occurred in the two level group (nine) than in the single level group (four).

**Literature Review–Multiple Disc Prostheses Compared to Fusion:** In 2009 Berg and colleagues reported the results of a prospective RCT (n=152) comparing total disc replacement with lumbar fusion. Disc replacement patients were randomized to one of three devices: Charité, ProDisc or the Maverick (not FDA approved). The fusion approach was either posterior lumbar or posterior lumbar interbody fusion. The follow-up rate was 100% at both one and two years. Outcome measures included global assessment (GA), VAS for back and leg pain, ODI, SF-36 and EQ5D. All outcomes improved in both groups postoperatively compared to preoperative scores. The GA indicated that 30% in the disc group were pain free at one and two years; 10% in the fusion group were pain free at one year and 15% were totally pain free at two years. The disc group reached a maximum recovery at one year in regards to VAS back pain, ODI, EQ5D, SF-36, however differences were not seen at two years. The fusion group continued to improve and at two years had results similar to the disc group. Additionally the authors reported there were no differences in outcome between one or two level surgery, the devices implanted, or between the two different fusion techniques. Return to work status was more rapid initially for the disc group; at three months 30% returned to work compared to 18% of the fusion group. At two years however the differences were minimal; 76% and 72% for the disc group and fusion group respectively (Berg, et al., 2010). Complication rates and reoperations rates were similar for both groups. According to the primary outcome measure (i.e., GA), at two years twice as many disc patients had total pain relief compared to the fusion group.

**Other Lumbar Prostheses:** There are several artificial disc replacement (ADR) devices that are being studied for use in the lumbar spine. Until approval can be obtained through the FDA, and clinical trials are conducted that provide guidance on specific patient selection, or patient net health outcomes, the use of these devices for the treatment of lumbar degenerative disc disease remains investigational. Some of these devices include (This list may not be all inclusive):

- Maverick (Medtronic Sofamor Danel, Memphis, TN)
- FlexiCore™ Intervertebral Disc (Stryker Spine, Allendale, NJ)
- AcroFlex® (DePuy Acromed, Raynham, MA).

**Lumbar Technology Assessment/Guidelines:** In 2005 several organizations reviewed the available literature and published recommendations regarding safety and efficacy of lumbar artificial disc replacement (Cochrane, 2005; California Technology Assessment Forum [CTAF], 2005; Institute for Clinical Systems Improvement [ICSI], 2005). All of these reports concluded there was insufficient data to adequately assess the performance of total disc replacement and further evidence is required regarding long term clinical outcomes.

In 2007 the Blue Cross Blue Shield Association (BCBSA) Technology Evaluation Center (TEC) published their evaluation of artificial lumbar disc replacement. Based on the available evidence (case series, randomized controlled trials for the Charité and ProDisc) the committee determined the evidence was insufficient to conclude whether the use of artificial lumbar discs improved net health outcomes or whether they were as beneficial as any established alternatives. The TEC assessment indicates that the effectiveness of fusion for chronic DDD is not well established, both noninferiority trials may not provide evidence of effectiveness, specific noninferiority margins are not justified, and lower than expected success rates raise additional questions for validity. The randomized trials did not prove superiority. BCBSA TEC concluded the use of artificial lumbar discs for degenerative disc disease did not meet the TEC criteria.

In 2009, the National Institute for Health and Clinical Excellence (NICE) published an update to their 2005 guidance (without change to position) on intervertebral lumbar disc prosthesis and considered the evidence on safety and efficacy adequate to support the use of the procedure under normal arrangements (NICE, 2009). NICE acknowledged that although some studies have a follow-up of 13 years, a majority of the evidence is from studies with a shorter duration of follow-up.

ECRI reported their findings on the intervertebral disc replacement prostheses in an Emerging Technology Evidence Report (ECRI, 2009a). The evidence reviewed included systematic reviews, two randomized controlled trials (one each evaluating Charité and ProDisc-L), seven comparison trials and nine case series. The evidence to address key issues for lumbar discs in general as identified by ECRI included two randomized trials. Those studies enrolled a total of 596 patients, 487 of whom provided data for 24-month follow-up. According to the report, these RCTs had several limitations that weaken the reliability of results, including failure to analyze data on an intent-to-treat basis (i.e., to account for all patients entered in the trial when analyzing outcomes data; patients who were lost to follow-up were not accounted for). The data suggest that AIDR may offer some potential advantages over spinal fusion in terms of reduced operative time, decreased length of hospital stay, and increased patient satisfaction. The short-term adverse-event rate for AIDR may be similar to that for spinal fusion. However, the rate and clinical impact of complications cannot be determined with the currently available data. The studies assessed different implants, and the safety and efficacy may differ between implants. Also, the impact, if any, of changing implant designs complicates assessment of the data. Furthermore, the safety data on lumbar AIDR are inadequate to draw conclusions about long-term safety. Long-term safety issues may be addressed more fully by the ongoing postmarket study assessing five-year safety and efficacy of the Charité Artificial Disc and ongoing trials for other implants.

**Summary Lumbar Intervertebral Disc Prostheses:** When measuring safety and efficacy outcomes at 24 months of follow-up, the Charité artificial disc was determined to be noninferior to ALIF with BAK cages and iliac autograft. Results from the five-year post market approval study have demonstrated results consistent with the two-year FDA IDE trial for this device. FDA approval for ProDisc<sup>®</sup>-L was based on a study comparing the device to a circumferential fusion technique which also demonstrated non-inferiority in safety and efficacy outcomes. The FDA-mandated five-year post market approval study for this device has yet to be completed. Studies to date show positive patient outcomes, including reduction of pain and improved motion, using the Charité and the ProDisc-L intervertebral disc devices for the treatment of DDD within the spine. The effect on adjacent spinal segments is not yet determined and continues to be investigated. Furthermore, additional studies are needed to determine the number of spinal levels that can be sequentially implanted in order to obtain the best patient results, or if the differences in the design of the two available devices result in different clinical outcomes. Data supporting long-term safety, efficacy and improvement of net health outcomes with the use of these devices are still being obtained.

### **Cervical Intervertebral Disc Prostheses**

Surgical decompression of the nerve root or spinal cord by anterior cervical discectomy and fusion, with or without plate fixation, using autologous or allogeneic bone is considered the standard surgical treatment for symptomatic cervical DDD when conservative measures have failed. Adjacent segment degeneration following cervical fusion is a concern however; Hilibrand et al. (1999) estimated that more than 25% of patients will develop adjacent segment disease during the first 10 years following cervical fusion and the risk of repeat operation after a prior fusion in half of all symptomatic patients. In hopes of restoring spinal motion and preventing adjacent segment disease, cervical intervertebral disc prostheses have been developed for use in patients with symptomatic cervical disc disease associated with DDD at a single level between C3 to C7. Cervical disc arthroplasty utilizes the same surgical approach as a fusion; however instead of using bone graft and anterior plate fixation during the arthroplasty, the surgeon secures a prosthetic disc into the intervertebral space. The device is designed to assist in maintaining vertebral height while decompressing the spinal cord or nerve root in the neck.

While the goal of each device is similar, their components and general design varies. Most of these prostheses are in various stages of research and clinical testing; several manufacturers have received investigational device exemptions. There are three cervical intervertebral disc prostheses that have been approved by the FDA for surgical implantation within the spine, for single-level cervical disc replacement: The Prestige<sup>™</sup> ST Cervical Disc (Medtronic Sofamor Danek, Memphis, TN), the PRODISC-C<sup>®</sup> Total Disc Replacement (Synthes, Inc., New York, NY) and the BRYAN<sup>®</sup> Cervical Disc (Medtronic Sofamor Danek, Memphis, TN).

**PRESTIGE<sup>™</sup> ST Cervical Disc:** The PRESTIGE<sup>™</sup> ST Cervical Disc consists of a two-piece articulating metal-on-metal device that is inserted into the intervertebral disc space at a single cervical level using an anterior approach. The components are affixed to the vertebral body by two bone screws through an anterior flange, and locked into place with a lock screw mechanism. This prosthesis is designed to allow the following motions ex-vivo: a minimum of 10 degrees motion off the neutral position in flexion/extension and lateral bending,

unconstrained axial rotation, and two millimeters (mm) of anterior/posterior translation. (This device has been modified since its original design, and previous versions have included the Bristol/Cummins disc, the Prestige I and the Prestige II.)

**U.S. Food and Drug Administration (FDA):** In July 2007, the FDA granted a premarket approval for the PRESTIGE™ ST Cervical Disc prosthesis. According to the manufacturer and the FDA premarket approval, this device is indicated for use in a skeletally mature patient for the reconstruction of a cervical disc from C3–C7 following single-level discectomy for intractable radiculopathy and/or myelopathy. The intractable radiculopathy and/or myelopathy (i.e., herniated disc, and/or osteophyte formation) should be severe enough to produce symptomatic nerve root and/or spinal cord compression, documented by patient history (e.g., neck and/or arm pain, functional deficit, and/or neurological deficit) and radiographic studies (e.g., CT, MRI, x-rays).

According to the FDA the Prestige Cervical Disc prosthesis is contraindicated in patients with an active infection or with an allergy to stainless steel. In addition, the safety and effectiveness of this device has not been established in patients with the following conditions:

- more than one cervical level with DDD
- not skeletally mature
- clinically significant cervical instability
- prior fusion at an adjacent cervical level
- severe facet joint pathology or involved vertebral bodies
- prior surgery at treated level
- osteopenia, osteomalacia, or osteoporosis as defined by bone mineral density T-score of -3.5, or -2.5 with vertebral crush fracture
- spinal metastases
- chronic or acute renal failure or history of renal disease
- taking medications known to potentially interfere with bone/soft tissue healing (e.g., steroids)
- pregnant
- severe insulin-dependent diabetes

The safety and effectiveness of the use of this device has also not been established in patients who have not undergone six weeks of conservative treatment or had signs of progression or spinal cord/nerve root compression with continued nonoperative care.

As part of the approval, the FDA is requiring a seven-year post-approval study to evaluate long-term safety and effectiveness of the Prestige ST Cervical Disc. Data will be collected at three, five and seven years postoperatively for all patients. Outcome measures will include Neck Disability Index (NDI) scores, radiograph information and neurological status as well as detailed information regarding adverse events.

**Literature Review—PRESTIGE ST Cervical Disc:** Mummaneni et al. (2007) conducted a prospective, randomized controlled study under an FDA-approved IDE to assess the safety and effectiveness of the PRESTIGE ST Cervical Disc System. This study compared anterior cervical discectomy with fusion and plating to cervical discectomy with immediate arthroplasty and insertion of the PRESTIGE ST Cervical Disc System. Five hundred and forty-one patients with single-level cervical DDD between C–3 and C–7 and intractable radiculopathy, myelopathy or both, were randomized into an investigational group (n=276) and a control group (n=265) within 32 institutions. Patients in the investigational group received a PRESTIGE ST Cervical Disc system prosthesis, and individuals in the control group underwent interbody fusion with cortical ring allograft and supplemental fixation using cervical plating. All patients entering the study had Neck Disability Index (NDI) scores of 30 or greater and numeric pain scores greater than or equal to 20. Prior to surgery, patients received six weeks of medical management (e.g., physical therapy, a reduction in activities, and anti-inflammatory medications) unless progressive neurological worsening occurred.

Mummaneni reported that the 24-month overall follow-up rate was 80% (223 of 276) in the investigational group and 75% (198 of 265) in the control group. Patients were counted as treatment failures if data could not be obtained during this 24-month period. The most commonly treated cervical level was C5–6, followed by C6–7. Secondary surgery occurred within both groups. No revisions occurred in the investigational group, while five revisions occurred within the control group. Implant removal was required in both groups (1.8%—investigational versus 3.4%—control), but these rates were not determined to be statistically significant. Reoperations were

required for adjacent-segment disease in both groups, with a statistically significant lower rate occurring in the investigational group ( $p=0.0492$ ) versus the control group. During the perioperative period, 17 adverse events (6.2%) occurred in the investigational group and 11 (4.2%) occurred in the control group. These events included hematoma formation, dysphagia, and dysphonia. Neck Disability Index (NDI) scores in both groups improved significantly over preoperative scores ( $p<0.001$ ), with statistical significance noted at six weeks and at three months for the investigational group. Neck pain scores improved significantly throughout the study in both groups, with no statistical difference noted in arm pain improvement between the groups.

At 24 months, neurological success was measured by motor function, sensory function, and deep tendon reflexes within each group (92.8% in the investigational group versus 84.3% in the control group). At 24 months, the incidences of employment were 75.4% and 74.7% (investigational versus control group). No implant failures, migrations, or subsidence were found; one case of ectopic ossification was noted in the investigational group. Preoperative radiographic angulation was 7.55 degrees in the investigational group; it was 7.59 degrees at 12 and 24 months. Evidence of fusion in the control group was high at 12 (98.7%) and 24 (97.5%) months. Overall success rates were determined by comparing the investigational group to the control group for the following:

- a noninferiority margin of 0.10 (determined by the FDA)
- Neck Disability Index (NDI) improvement scores would be measured in relation to preoperative measures with a 15 point or greater score being required to be considered successful.
- SF-36 PCS and MCS scores (patient reported scores for physical function, bodily pain and emotional-mental scales) would be compared to those obtained before surgery.

Expectations for improvement would include decreasing NDI scores with improving scores on the SF-36 PCS and the MCS ratings. Overall success for the investigational group was 77.6% at 12 months and 79.3% at 24 months. Overall success for the control group was 66.4% at 12 months and 67.8% at 24 months. The researchers determined that the outcomes proved the device was noninferior to anterior cervical discectomy with fusion (ACDF) ( $p<0.0001$ ) at both 12 and 24 months. They also determined that neurological functioning outcomes were statistically superior ( $p=0.0040$ , 12 months;  $p=0.0053$ , 24 months).

Burkus et al. (2010) published five-year results of a prospective nonblinded, multicenter RCT (32 centers,  $n=541$ ) comparing cervical disc replacement using the Prestige disc ( $n=276$ ), with anterior instrumented interbody fusion ( $n=265$ ). The study was conducted under an approved IDE; patients in the IDE were followed up in this FDA regulated post-approval study to determine outcomes at five years, and to compare the five year data to the data from the two-year study. All surgeries were performed at a single disc space level between C3-C4 and C6-C7. All patients had neck and arm pain which continued despite nonoperative treatment for at least six weeks prior to surgery. One center did not participate in the long term follow-up study leaving 533 subjects eligible for the post-approval study. Of those patients, 271 have completed the 60-month follow-up. Since the 36-month follow-up occurred between the IDE trial and the post-approval phase, 197 patients of the investigational group and 160 of the control group were evaluated at 36 months. Data reported in this trial included the 36 month data which was completed after the initial IDE trial through the 60-month time period.

Clinical outcome measures included NDI, SF-36 PCS, neck and arm pain scores, and return to work status. Plain radiographs were obtained preoperative, intraoperatively and at various time periods through the 60 month follow-up. Secondary surgical procedures at the index level were classified as revision, removals, supplemental fixations or reoperations. The results, similar to those seen at 24 months, were as follows:

- NDI scores improved an average of 36.3 points and 38.4 points in the investigational group at 36 and 60 months respectively from a mean preoperative score of 55.7, compared to the control group scores of 31.3 points and 34.1 points and a mean preoperative score of 56.4. The differences were significant and favored the disc treatment group.
- Neck pain scores improved an of average of 53.8 points and 56 points at 36 and 60 months respectively from a mean preoperative score of 68.2, compared to 49.2 points and 52.4 points in the control group, and a preoperative score of 69.3.
- Arm pain scores improved an average of 47.1 points and 52.5 points at 36 and 60 months respectively, from a mean preoperative score of 59.1, compared to the control group scores of 45.0 and 47.7 points respectively and a preoperative score of 62.4.

- SF-36 scores improved an average of 13.6 points and 14.7 points at 36 months and 60 months respectively from a preoperative score of 31.9, compared to the control group scores of 11.1 points and 12.9 points respectively, and a preoperative score of 32.0.
- Neurological success rates in the investigational group overall were high, exceeding 90% at all follow-up intervals, the reported rates were 91.6%, 92.8%, and 95.0% at 24, 36 and 60 months respectively; compared to 83.6% , 83.2% and 88.9% in the investigational group, at the same follow-up periods.
- At 60 months the percentage of working subjects in the investigational group was 76.3% versus 72.6% in the control group, there was no significant difference between groups.

In the control group sagittal motion was restricted after surgery whereas in the treatment group the Prestige implant effectively maintained sagittal motion averaging 7.3° at 36 months and 6.5° at 60 months. There were no implant migrations and no statistically significant difference between subsidence rates. Adjacent segment ossification was not a specific data point in the study. Complaints of dysphagia and dysphonia were similar among both groups, at 24 months the control group had a rate of 8.3% rate compared to 8.7% in the treatment group. Both groups had secondary surgical procedures performed and were reported as follows in the control versus treatment group respectively: revision surgeries (5 versus 0), supplemental fixation (3.4% versus 0%); implant removal (4.9% versus 2.5%); reoperation rate (.8% versus 1.4%); adjacent level surgery (13 patients versus 8 patients). Regarding the rate of revision and the supplemental fixation rate, the differences were statistically significant and favored the investigational group. The authors concluded the Prestige disc maintains improved clinical outcomes at five years following implantation.

**Early Models of the PRESTIGE Cervical Disc:** Wigfield et al. (2002) reported on results from a two-year pilot study using a newly remodeled semi-restrained Frenchay artificial cervical joint (previously referred to as the Bristol-Cummins device). The redesign of this device was to allow for more physiologic motion once implanted, and the aim of this prospective cohort study was to assess device safety, stability and ensuing motion following surgery (n=15). At 24 months follow up device stability was noted in all patients, and there was no incidence of joint dislocation. Patient questionnaires revealed improvement in all aspects of patient function and quality of life (arm pain improved by 46%; neck pain improved by 45%; NDI scores improved 31%; PCS and MCS scores improved 14 and 2%, respectively).

Robertson and Metcalf (2004) reported the four-year post-implant results from the original group of patients implanted with the Frenchay and the new smaller Prestige I device. At 48 months, 14 artificial devices had been implanted in 12 patients. Results from patient questionnaires at 48 months continued to show improvement in all aspects of patient function and quality of life with decreased arm and neck pain and improved NDI scores. The authors concluded results demonstrated that the Prestige I device is capable of maintaining function at four years without the development of adjacent segment disease.

Following this study, the designers of the Prestige cervical device modified its shape, improved its surface to enhance bone ingrowth, and created additional sizes to maintain its already proven articulation ability. The newer device was called the Prestige II (Porchet, 2004). As a result of this redesign, Prochet et al. (2004) conducted a multicenter, prospective, randomized controlled study to evaluate its safety and effectiveness compared to an anterior cervical fusion for the treatment of single-level DDD. Inclusion criteria consisted of:

- cervical DDD, defined as an intractable radiculopathy or myelopathy caused by neuro-radiographically documented disc herniation or osteophyte formation
- unresponsiveness to nonoperative treatment for approximately six weeks or the presence of progressive symptoms of signs of nerve root compression while nonoperative management was continued
- age older than 18 years
- preoperative NDI score > 30

Fifty-five patients were enrolled, with 27 randomized into the investigational group receiving ACDA with the Prestige II disc; and 28 entered the control group, receiving ACDF with iliac crest autograft. At 12 months, 37 patients had been evaluated, and nine patients had been evaluated at the 24-month interval.

Porchet found 19 adverse events within the ACDF group and seventeen adverse events that occurred within the investigational group; the number of adverse events between the ACDF and the ACDA was not significantly different. Radiographic evaluations at 12 months for 22 patients in the ACDA group and 14 patients in the ACDF group showed the device to have a mean angular motion of 5.9 degrees, and the fusion group had a mean

angular motion of 1.1 degrees (considered “no motion”). No significant differences were noted for these outcomes. At 24 months, NDI improvement was equivalent between the treatment groups ( $p < 0.05$ , non-inferiority margin = 10). Neck pain scores were significantly improved in both groups over the preoperative levels, but these findings were also determined to be statistically equivalent. Arm pain scores also improved significantly in both groups, with statistical equivalence of ( $p < 0.05$ ; non-inferiority margin = 10) noted up to the 24-month interval. Patient reported SF-36 quality of life scores also improved within both groups but did not reach a statistically significant difference. The researchers concluded that while early results appear promising for the Prestige II device, intermittent and long-term outcome-based studies are necessary to prove superiority or equality to the current gold standard of ACDF. The clinical and radiographic results show the Prestige II disc alleviates pain and symptoms comparably to fusion while maintaining motion at the treated level.

**PRODISC-C® (Synthes, Inc., New York, NY):** The ProDisc-C Total Disc Replacement is composed of three components: a cobalt chromium molybdenum alloy plate that is anchored into the inferior vertebral body, an ultra-high molecular weight polyethylene insert that is attached to the alloy plate providing a inferior convex bearing surface, and a second cobalt chromium molybdenum alloy plate that anchors to the superior vertebral body and has a concave bearing surface. The device forms a ball and socket joint and allows unconstrained axial rotation.

**U.S. Food and Drug Administration (FDA):** In December 2007, the FDA granted a premarket approval for the ProDisc-C Total Disc Replacement prosthesis. Based on the information provided from the manufacturer and the FDA premarket approval, this device is indicated for use in skeletally mature individuals for the reconstruction of the disc from C3–C7 following single-level discectomy for intractable symptomatic degenerative disc disease (SCDD). SCDD is defined as neck or arm (radicular) pain and/or functional /neurological deficit with imaging confirmation (i.e., CT, MRI, X-rays) of at least one of the following conditions: herniated nucleus pulposus, spondylosis (defined by the presence of osteophytes) and/or loss of disc height. Candidates for this device should have failed at least six weeks of nonoperative treatment (e.g., physical therapy, medication) prior to implantation.

The FDA has reported this device is contraindicated in people with the following conditions:

- active systemic infection or infection localized to the site of implantation
- osteoporosis
- marked cervical instability on neutral resting lateral or flexion /extension radiographs
- allergy or sensitivity to implant materials
- severe spondylosis
- compromised vertebral bodies at the affected level
- individuals with SCDD at more than one level

Safety and effectiveness of this device has not been established in patients with the following conditions:

- skeletally immature patients, pediatric or adolescent children (<21 years old)
- over the age of 60
- more than one vertebral level with SCDD
- prior fusion surgery at an adjacent vertebral level
- prior surgery at the level to be treated
- patients with progressive symptoms and signs of spinal cord/nerve root compression with less than six weeks of conservative treatment
- facet joint disease or degeneration at the level to be treated
- neck or arm pain of unknown etiology
- Paget's disease, osteomalacia, or other metabolic bone disease
- pregnancy
- taking medications known to potentially interfere with bone/soft tissue healing (e.g., steroids)
- rheumatoid arthritis or other autoimmune disease
- severe diabetes mellitus requiring daily insulin treatment
- systemic disease including AIDS, HIV, and Hepatitis
- active malignancy

Similar to the Prestige ST cervical disc, the FDA is requiring a post-approval study be conducted to evaluate long-term safety and effectiveness of the ProDisc-C Total Disc Replacement. Overall success parameters have been defined by the FDA in addition to guidance for radiological parameters evaluating adverse events and adjacent segment degeneration.

**Literature Review— PRODISC-C®:** Nabhan and colleagues (2007) reported on the results of a prospective randomized controlled study evaluating segmental motion following artificial disc replacement with the ProDisc-C device over one year. The authors compared segmental motion and clinical results to the “gold standard” anterior cervical discectomy and fusion. The study population consisted of 49 patients with clinical evidence of radiculopathy, unresponsive to conservative treatment and/or progressive radicular deficits. Twenty-five patients received disc replacement and 24 were treated with fusion. Eight patients were excluded due to ineligibility for roentgen stereometric analysis, leaving 41 for the RCT, one patient died during the trial period. Clinical symptoms of neck and arm pain were evaluated at baseline and at one, three, six, 12, 24 and 52 weeks after surgery. VAS was used for grading neck and arm pain. Results from the study demonstrated that mean value and standard deviation for segmental motion after disc implantation one week postoperative was 2.3 (1.1) decreasing to 0.8(.41) after 52 weeks; at three weeks there was a significant decrease in motion compared to one week. For weeks 12, 24 and 52 there was no significant difference in comparison to the six week value. The control group values were 0.60 (2.2) at one week decreasing to 0.1 (0.3) at 52 weeks; at three weeks there was a significant decrease in motion and a further decrease at six weeks although not statistically significant. The 12, 24 and 52 week values were not significantly different compared to the six week value. Radiograph examination did not show any signs of calcification or loosening of the bone around the prosthesis. There was no deformity in the fusion group; calcification was not seen six months after surgery. At one year there was no sign of adjacent level degeneration in either group. Mean VAS scores for neck and arm pain decreased significantly in both groups from preoperative to 52 weeks after surgery. The authors acknowledged that cervical spine motion decreased over time in both the prosthesis and fusion group although the loss was significantly higher in the fusion group at one year postoperatively. Additionally, pain relief was comparable in both groups; the prosthesis restored segmental stability, and furthermore (in the author’s opinion) the device may avoid adjacent segment degeneration. The authors noted further studies are warranted with long-term follow-up to ascertain whether or not cervical motion is preserved following disc replacement.

Murrey et al. (2008) conducted a prospective, randomized controlled study under an FDA-approved IDE study (noninferiority design) to assess safety and effectiveness of the ProDisc-C Total Disc Replacement. The study population involved 209 patients with symptomatic cervical degenerative disc disease causing intractable debilitating radiculopathy from one vertebral segment (between C3 and C7) who were unresponsive to nonoperative treatment for at least six weeks and had neck disability index scores of 15/50 (30%) or more. The study compared ProDisc-C (n=103) to a control group who received anterior cervical discectomy and fusion (n=106). Overall success was determined by four-component endpoints: NDI success (defined as a 15 point improvement from baseline value), neurological success (defined as the maintenance of improvement of each neurologic evaluation [sensory, motor, reflex functions], device success and absence of adverse events related to the device or its implantation with ratings defined as the percentage of individual patients achieving success in all four-component endpoints. The clinical status of each patient was evaluated pre and postoperatively at six weeks, three, six, 12, 18 and 24 months and included self-assessment, physical and neurological examination and radiograph evaluation.

The follow-up rate at 24 months for the entire group was 96.5% and the authors noted there were no statistically significant differences between ProDisc-C patients (98.0%) and control patients (94.8%) returning at 24-months. The authors reported the following outcome measures:

- **Cervical Disc Level:** The cervical disc level most commonly treated was level C5–C6 followed by C6–C7.
- **Intraoperative measures:** Both operative time and blood loss were lower for the fusion group compared to the ProDisc-C group and were statistically significant (fusion 98.7 minutes vs. ProDisc-C 107.2 minutes [p=0.0078]; fusion 63.5cc vs. ProDisc-C 83.5cc [p=0.0094], respectively).
- **Neurological success:** At six months there was a statistically significant difference in neurological success that favored the ProDisc-C group—94.6% achieved success compared with 85.1% of the fusion group (p=.0460). Although not statistically significant, at 24 months the neurological success rate favored the ProDisc-C group (90.9%) compared with the fusion group (88.0%).

- **NDI scores:** All patients demonstrated statistically significant improvement in scores at all follow-up periods compared with baseline ( $p < .0001$ ). At three months the results favored the ProDisc-C and at 24 months the mean score for the ProDisc-C was  $21.4 \pm 20.0$  points whereas the mean score for the control group was  $20.5 \pm 18.4$  points ( $p = 1.0000$ ). At all time periods the success rate was higher for the ProDisc-C group. At 24 months 79.8% of ProDisc-C patients were considered successful and had more than a 15-point improvement; 78.3% of the control group was considered successful.
- **Secondary Surgical Procedures:** Nine patients in the control group required a secondary surgical procedure (five required revision, zero removals, one re-operation, three supplemental fixation) while two patients in the ProDisc-C group required additional procedures (zero revisions, two implant removals, zero re-operations, zero supplemental fixation).
- **Devices success** (Defined as no revision, removal, re-operation or supplemental fixation): There was a 98.1% success rate in the ProDisc-C group compared to the control group with 91.5%, which was statistically significant ( $p = .033$ ).
- **Adverse events:** Adverse event success (absence of adverse events) was higher in the ProDisc-C group (97.1%) when compared to the control group (93.4%), although not statistically significant.
- **Visual Analog Scale (VAS):** At 24 months, VAS scores for were similar between groups for all parameters tested (neck pain, arm pain, and frequency). A 20% improvement in neck or arm pain frequency at 24 months was achieved successfully by 87.9% of the ProDisc-C group and 86.9% of the control group.

There was no evidence of migration, subsidence, change in disc height, or visible gaps found on radiograph assessment in either group at 24 month follow-up. The fusion rate for patients who did not require a secondary surgery at 24 months was 90.2%. A total of 84.4% of ProDisc-C patients achieved a more than or equal to 4° of motion or maintained motion relative to preoperative baseline at the operative level. At 24 months, 80.0% of the fusion group returned to work compared to 82.8% of the ProDisc-C group.

Based on FDA criteria for success, 72.3% of ProDisc-C patients and 68.3% of fusion patients were successful at 24 months. The additional minimally clinically important difference (MCID) found 73.5% of ProDisc-C patients and 60.5% of fusions patients successful at 24 months. The authors concluded that the ProDisc-C is proven as safe and effective compared to standard treatment of anterior cervical discectomy and fusion.

**BRYAN® Cervical Disc (Medtronic Sofamor Danek, Memphis, TN):** The BRYAN cervical disc is composed of a plastic (polyurethane) center with titanium endplates. It is designed as a one-piece device that allows unconstrained motion. According to the manufacturer, the BRYAN cervical disc is indicated for use in skeletally mature patients with cervical degenerative disc disease (DDD) at one level from C3–C7.

The BRYAN cervical artificial disc is unique in that there is a flexible membrane that surrounds the nucleus (the inner portion of the disc) that is filled with a lubricant. This membrane is designed for two purposes: to contain any wear debris that forms and to prevent any soft tissue in-growth. The articulating surfaces of this device are polyurethane on titanium. It has beaded porous coated endplates intended for biological fixation instead of fixation using screws into the vertebrae or fixation by use of stabilizing keels.

**U.S. Food and Drug Administration (FDA):** In May 2009, the FDA granted a premarket approval for the BRYAN Cervical Disc. Based on the information provided from the manufacturer and the FDA premarket approval, the device is indicated in skeletally mature patients for reconstruction of the disc from C3-C7 following single-level discectomy for intractable radiculopathy and/or myelopathy. The BRYAN® device is implanted via an open anterior approach. Patients receiving the BRYAN® Cervical Disc should have failed at least six weeks of non-operative treatment prior to implantation of the device.

The FDA has defined intractable radiculopathy and/or myelopathy as any combination of disc herniation with radiculopathy, spondylotic radiculopathy, disc herniation with myelopathy, or spondylotic myelopathy resulting in impaired function, and at least one clinical neurological sign associated with the cervical level to be treated, and necessitating surgery as demonstrated using computed tomography (CT), myelography and CT, and/or magnetic resonance imaging (MRI).

Similar to other FDA approved cervical disc replacement devices, the FDA is requiring a post approval study to evaluate the safety and effectiveness of the BRYAN Cervical Disc. Data is to be collected at five, seven and 10

years (due to the polyurethane articulating surface) and include NDI, radiographic information, neurological status, heterotopic ossification, disc orientation and adjacent level disease, as well as other outcomes as measured in the IDE study. The FDA is also requiring data for explanted devices and all adverse events including details of the nature, onset, duration, severity, relationship to the device, and relationship to the operative procedure and outcome, reported for these patients. A five-year enhanced surveillance study is also being required to more fully characterize adverse events when used in a broader population.

The FDA has indicated the device is contraindicated in patients with the following conditions:

- active systemic infection or infection at the operating site
- allergy to titanium, polyurethane, or ethylene oxide residues
- osteoporosis defined as a DEXA bone mineral density T-score equal to or worse than -2.5
- moderate to advanced spondylosis characterized by bridging osteophytes, marked reduction or absence of motion, or collapse of the intervertebral disc space of greater than 50% of its normal height
- marked cervical instability on radiographs (e.g., radiographic signs of subluxation greater than 3.5 mm or angulation of the disc space more than 11 degrees greater than adjacent segments)
- significant cervical anatomical deformity or compromised vertebral bodies at the index level (e.g., ankylosing spondylitis, rheumatoid arthritis, or compromise due to current or past trauma)
- significant kyphotic deformity or significant reversal of lordosis
- symptoms necessitating surgical treatment at more than one cervical level

In addition, the safety and effectiveness of this device has not been established in patients with the following conditions:

- axial neck pain as solitary symptom
- not skeletally mature
- prior cervical spine surgery, including prior surgery at the Index level
- facet joint pathology of Involved vertebral bodies
- active malignancy
- Paget's disease, osteomalacia, or other metabolic bone disease
- chronic or acute renal failure or history of renal disease
- taking medications known to potentially Interfere with bone/soft tissue healing (e.g. steroids)
- pregnant
- unstable cardiac disease
- diabetes mellitus requiring daily insulin management
- extreme obesity as defined by the NIH Clinical Guidelines Body Mass Index (i.e., DM1 SO).

The safety and effectiveness of this device has also not been established in patients who have undergone less than six weeks of conservative treatment or in those who had signs of progression or spinal cord/nerve root compression with continued nonoperative care.

**Literature Review—BRYAN® Cervical Disc:** Goffin et al. (2002 [b]) reported the preliminary results from a prospective multicenter study that was designed to determine if the BRYAN disc could provide relief from objective neurological signs and symptoms, improve the patient's ability to perform activities of daily living (ADLs), decrease pain, and provide stability and normal range of motion (ROM) when implanted at a single level of the cervical spine. The benchmarks for improvement were set as: excellent (at least 80% improvement, with no more than 10% deterioration); good (at least 70% improvement, with no more than 15% deterioration); fair (at least 50% improvement, with no more than 20% deterioration); and poor (less than 50% improvement, more than 20% deterioration).. Sixty of these patients were followed for six months and 30 were followed for one year. At six months, the results were excellent, good or fair for 52 (86%) of the 60 patients evaluated. At one year, the scores were excellent, good or fair for 27 (90%) of the 30 patients evaluated. Adverse events included dysphonia, insufficient decompression requiring additional surgery, and a prevertebral hematoma developed as a result of a blocked drainage tube. Device migration did not exceed three millimeters in any patient. Six-month ROM was  $\geq 2$  degrees in 53 (93%) of 57 patients; at one year, ROM was  $\geq 2$  degrees in 21 (88%) of 24 patients. The researchers reported improved ADL scores at six and 12 months. The researchers noted that long-term follow-up of at least five years is needed to determine if the device remains functional and the impact this device may have on adjacent vertebral segments.

Goffin and colleagues (2003 [a]) reported on a second arm of the original prospective trial that was initiated in 2001 to evaluate the use of the BRYAN cervical disc implant at a single- and bi-level of the cervical spine. The benchmarks for success were measured by using the Cervical Spine Research Society Patient Questionnaire, which measures pain relief and neurological improvement. Single-level implantation occurred in 103 patients, and 43 patients received a bi-level implantation. In the single-level group, 100 patients have reached their 12-month follow-up and 51 patients have reached their 24-month follow-up. In the single-level study group, complete data was available for 92 of these patients. Outcome data at six months was excellent, good and fair in 83 (90%) patients. At one year, their neurological scores were excellent, good or fair for 76 out of 89 patients (86%). At two years, of the 49 patients with data, 44 (90%) had scores of excellent, good or fair. Adverse events within the single-level group included unresolved pain and residual myelopathy, reoperation due to the device being inserted in the wrong level during the initial surgery, and one patient had radiculopathy at an adjacent level and required a second BRYAN implant. Goffin noted in the bi-level study group, six-month reported scores were excellent, good or fair in 28 (82%) of 34 patients. At one year, scores of excellent, good or fair were reported for 25 out of 26 patients (96%). Adverse events in the bi-level group included a cerebrospinal fluid leak occurred at the time of spinal decompression, a prevertebral hematoma was evacuated, a repair of a pharyngeal tear/esophageal wound occurred, and an additional anterior decompression occurred due to ongoing nerve root compression. No device failures or device explants were reported. At one year, 88% of the patients in the single-level group and 86% of the patients in the bi-level group exhibited motion  $\geq 2$  degrees. At two years, 93% of the patients in the single-level study exhibited motion  $\geq 2$  degrees. The authors acknowledged that five-year follow-up is needed to determine long-term device functionality and its relative impact on adjacent cervical segments.

Robertson et al. (2005) compared data from two prospective studies to document radiological changes and symptomatic adjacent-level cervical disc disease after single-level discectomy and subsequent cervical fusion or arthroplasty with the BRYAN cervical disc prosthesis. This cohort of patients included 158 with cervical fusions and 74 with BRYAN discs that were followed 24 months after their initial surgery. Radiological evidence of adjacent-level disease included new anterior osteophyte formation or enlargement of existing osteophytes, increased or new narrowing of a disc space ( $\geq 30\%$ ), and new or increasing anterior longitudinal ligament (ALL) calcification. Robertson and colleagues noted that in the fusion group, new osteophyte formation in the superior adjacent space was noted in 85% of the patients and in the inferior space in 15%; whereas, in the BRYAN group all osteophytes were new and only one was located in the inferior adjacent space. The researchers concluded that: 1) the presence of moderate or severe kyphosis if present at the symptomatic level may be a contraindication for use of the BRYAN disc; 2) radiographic findings demonstrate changes in the adjacent levels of the spine after fusion within 24 months ( $p=0.009$ ), as well as adjacent-level symptomatic cervical disc herniation ( $p=0.018$ ); and 3) it appears that maintaining motion after single-level cervical discectomy may delay or prevent symptomatic postoperative disc disease. It is hard to determine the degree of clinical improvement regarding decrease in pain or improved function as two types of evaluation tools were used, and the outcomes of only one was available during this study.

Sasso et al. (2007a) reported a subset of data from 115 patients who participated in the FDA IDE study of the BRYAN<sup>®</sup> cervical disc. At 12 months, data from 109 patients were available; data from 71 patients were available at 24 months. Outcomes from these groups were determined by comparing preoperative PCS, NDI and VAS pain scores to those recorded at each follow-up time. Expectations included a decrease in NDI, with improvement levels noted in both PCS and VAS scores for neck and arm pain.

Sasso reported that both groups had significant changes from baseline PCS to the scores obtained at 24 months. The degree of NDI improvement was significantly greater in the BRYAN group at 12 months versus the fusion group. At 24 months, the NDI change from preoperative levels was significant for both groups ( $p<0.001$ ). Neck pain improvement at 12 months was determined to be equivalent between each group. At 24 months, neck pain improvement seemed to be significantly better in the BRYAN group ( $p=0.014$ ); however, there was significant improvement over preoperative scores noted in both groups ( $p<0.001$ ). At 24 months, no group-to-group differences were noted, as both groups improved significantly over preoperative scores ( $p<0.001$ ). The disc replacement group retained an average ROM of 7.3 degrees at 12 months and 7.0 degrees at 24 months. By 24 months, there was no statistically significant change noted over preoperative measurements. Three patients in the investigational group required ACDF due to adjacent level disease during the 24 months of follow-up. No spontaneous fusions or heterotopic ossification (HO) were noted in the BRYAN group. A total of 99 subjects were available for 24 month follow-up and reported on by Sasso and colleagues later in 2007. Within this publication the author's conclusions remained unchanged (Sasso, et al. 2007b).

Anderson and colleagues (2008) published the results of a randomized controlled clinical trial evaluating the adverse events associated with the BRYAN artificial disc compared to anterior cervical arthrodesis during the FDA IDE study. Adverse events were defined as those events that may affect patient outcome, require intervention, or that need further diagnostic tests or monitoring. The events could have occurred at any time during surgery, initial hospitalization, or follow-up through 24 months. The control group underwent arthrodesis with allograft and titanium alloy plate and screw construct (n=221) while the investigational group received the BRYAN Disc (n=242). Inclusion criteria were single-level cervical DDD causing radiculopathy or myelopathy in skeletally mature patients from C3 to C7 who failed conservative therapy for at least six weeks and who had NDI scores equal to or greater than 30%. Evaluations occurred prior to surgery, at the time of surgery and after surgery at six weeks, three months, six months, 12 months and 24 months. At 24 months the composite follow-up rate for both treatment groups was 90%. The severity of events were graded according to the World Health Organization (WHO) scale (i.e., Grade 1 events did not require treatment, Grade 2 may have required nonoperative treatment, Grade 3 required medical treatment and Grade 4 required an operation). The authors also graded events according to medical events or surgical related. Medical events occurring six weeks or more after surgery were identified in 35.1% and 31.2% of the investigational and control groups, respectively; a majority which were for gastrointestinal and genitourinary events. Medical events occurring within six weeks of surgery were present in 14.9% and 15.4% of the investigational and control groups, respectively (not statistically significant). More adverse events related to the surgery occurred in the investigational group (33.9%) compared to the control group (29.0%) and were related to more superficial wound infections, dysphagia and cardiovascular events. Anesthesia related events were similar between groups. No differences were noted in acute medical events between groups. More surgical adverse events occurred in the investigational group as well as adverse neurologic symptoms. Significantly more Grade 3 and 4 events occurred in the control group. Reoperations on the cervical spine occurred in 5.4% of the investigational group and 7.7% of the control group.

Sasso colleagues (2008a) studied the ability of the BRYAN Disc to maintain motion at the implanted level and assessed range of motion (ROM) at the adjacent segments in comparison to arthrodesis. The study was part of the initial 22 patients enrolled in the FDA IDE trial at one center. Patients received either single-level anterior cervical allograft/plate or an artificial cervical disc at level C5–C6 or C6–C7. Flexion, extension, and neutral lateral radiographs were obtained preoperatively, immediately postoperatively, and at regular intervals for 24 months. The authors reported significantly more flexion/extension motion in the disc replacement group at index level. The disc replacement group retained an average range of motion of 6.7° at 24 months while the fusion group demonstrated 2° at three month follow-up and a decrease to 0.6° at 24 months. Flexion /extension ROM both above and below the operative level was not statistically different among groups. Mobility increased for both groups over time. The anterior/posterior translation occurring with flexion/extension remained unchanged for the disc group above the target disc pre and postoperatively whereas the translation increased at the level above the fusion. At six months the increase in translation was significantly greater in the fusion group compared to the disc group, although it was not significantly greater at 12 months.

Later in 2008 Sasso et al. (2008b) reported the results of a larger arm of the FDA IDE study (n=463) again evaluating kinematic analysis of target level and adjacent segment motion after BRYAN Disc replacement compared to anterior cervical fusion and noted more motion retained in the disc replacement group than the plated group at the index level. The authors reported that the disc replacement group retained an average ROM of 7.95° at 24 months. The fusion group demonstrated an average ROM of 1.11° at three month follow-up and gradually decreased to 0.87° at 24 months. Preoperative ROM in the disc group was 6.43° and 8.39° in the fusion group. There was no evidence of degradation of motion in the disc group at 24 months, no ectopic bridging ossification, and there was no case of subsidence of the BRYAN Disc.

Yang et al. (2008) published the results of a prospective study of patients who underwent single and multiple level arthroplasty with the BRYAN cervical disc system (n=19). Patients had single, two or three level disease between C3/4 and C6/7. Clinical outcomes were assessed using Japanese Orthopedic Association (JOA) scores and Odom's scale. VAS was used to evaluate pain scores. Radiograph assessment was conducted with anterior posterior and lateral radiographs of the cervical spine postoperatively and at six, 12, 18 and 24 months to find ROM and device position. A total of 16 patients had single-level diseases, two underwent 2-level replacement and one underwent 3-level replacement. All patients had significant pain relief and functional activity improvement during the follow-up period; mean JOA scores of 8.6 ± 1.8 and 15.8 ± 5.4 before surgery and at final examination were reported, respectively. The difference in scores was statistically significant. According to Odom's scale all 19 patients had excellent to good outcome in the early and immediate

postoperative period and the improvement continued at the last follow-up. VAS results were  $8.15 \pm 1.75$  before the operation,  $4.5 \pm 1.5$  at one week after the operation, and  $2.5 \pm 1.5$  at the end of the follow-up. The ROM recovered to the preoperative value during the follow-up ( $54.3 \pm 8.4^\circ$ ); the differences were not statistically significant. The treated segment showed preservation of motion when compared with preoperative levels. No prosthesis subsidence or excursion was found. In the author's opinion the literature supports safety of bi-level disc replacement; however the role for three-level replacement remains unproven. The researchers concluded the BRYAN disc seemed to be safe and resulted in encouraging clinical and radiographic outcomes. Nonetheless, long-term data are required to prove efficacy and its ability to prevent adjacent segment disease.

Heidecke et al. (2008) published their results of a prospective case series involving 54 patients who underwent disc replacement with the BRYAN cervical disc. Inclusion criteria were disc herniation and/or spondylosis with preserved mobility, cervical radiculopathy and/or myelopathy with or without neck pain. Patients were followed for two years postoperatively using Odom's criteria and cervical X-ray imaging. A total of 49 patients had single-level replacement and five had two adjacent segments replaced. According to Odom criteria 43 patients had excellent and 11 had good outcome at two years post surgery. One week after surgery radiographs demonstrated correct position and function of the implants in all patients. There was no migration or dislocation noted through out the study period. Dynamic lateral X-rays did show loss of function in seven patients with single-level implants. In the remaining 52 treated segments heterotopic ossification (HO) of grades 1 and 2 were seen in 12 levels, HO grades 3 and 4 were not seen. Surgery related complications included an early postoperative retropharyngeal hematoma that required surgical evacuation. In this small case series TDR with the BRYAN disc resulted in excellent or good neurological outcomes in all patients. Further studies with longer follow-up and a control group are necessary to support improvement in net health outcomes.

The results of a prospective, randomized, controlled, multicenter trial comparing cervical disc arthroplasty using the BRYAN cervical disc (n=242) to single-level anterior cervical discectomy (n=221) was published by Heller et al. (2009). The trial was a noninferiority trial designed to evaluate safety and effectiveness of the device. Neither group required cointervention; evaluations were conducted preoperative, surgery/discharge, 1.5, 3, 6, 12 and 24 months after surgery. Patient follow-up rates at 12 and 24 months were 93.1% and 91.6%, respectively. Clinical outcomes were measured using NDI, the SF-36, and numerical rating scales for arm and neck pain. Radiographs were obtained before surgery and throughout the follow-up periods. Neurologic success required improvement of three parameters (sensory, motor and reflexes). Overall success was determined by  $\geq 15$  point improvement in NDI scores, maintenance or improvement in neurological status, no serious events related to the implant or implant /surgical procedure, and any subsequent surgery or intervention that is classified as "failure". Statistically significant reduction in NDI scores, neck and arm pain were noted for both groups at every follow-up. The investigational group had a significantly greater NDI score improvement than the control group ( $P=0.025$ ) at all intervals and significantly greater improvement in neck pain at all intervals. Arm pain reduction was similar in both groups. At 24 months SF-36 scores significantly improved for both groups, but without statistical difference. Neurological success was similar for both treatment groups: 93.9% for the investigational group and 90.2% for the control group. Return to work status was similar for both groups at 24 months (73.6% control, 76.8% investigational) although at 1.5 and 3 months following surgery it was in favor of the investigational group. The median return to work interval was significantly different with the investigational group returning at an average of 48 days versus 61 days for the control group. Serious adverse events occurred in 31.0% of the investigational group versus 27.6% of the control group; 1.7% of the investigational and 3.2% of the control group were implant related or implant/surgery related. Within the 24 month follow-up period 2.5% of the investigational group versus 3.6% of the fusion group required secondary surgical procedures (revision, removal, supplemental fixation or reoperation). ROM increased in the investigational group from  $6.5^\circ$  to  $8.1^\circ \pm 4.8^\circ$ , fusion was successful in the 94.3% of the control group. Overall success at 24 months was achieved in 82.6% of the investigational group versus 72.7% in the control group, the difference was statistically significant. Similar differences were noted at 12 month follow-up. An intent-to-treat analysis showed overall success as 82.2% for the investigational group and 72.7% for the control group.

In a small case series Yang et al. (2009) retrospectively reviewed 15 patients who underwent cervical disc replacement with the Bryan disc prosthesis for single level disc disease and reported that JOA scores, VAS scores and NDI scores improved throughout the follow-up periods (12 and 24 months), the JOA was statistically significant at all time periods. ROM recovered to the preoperative level; preoperative lordosis and functional spinal unit improved. There was no evidence of subsidence, extrusion or heterotopic ossification noted and no recompression of the spinal cord or nerve root. The authors noted however further studies are required with larger populations to support improvement in long-term clinical outcomes.

Yi et al. (2009) reported the results of a retrospective case series (n=72) evaluating adjacent segment degeneration following single-level arthroplasties using a Bryan Cervical Disc prosthesis. Preoperative disc degeneration was documented by x-ray and MR studies. Radiological change was evaluated and evidence of adjacent segment disease included new formation or enlargement of anterior osteophyte, new or increasing ALL calcification or narrowing of the disc space documented on serial plain radiographs. Nine patients demonstrated evidence of adjacent segment degeneration (12.5%) at an average follow-up period of 24.2 months. The mean period of onset was 16.3 months. Four of the nine cases also showed various degrees of heterotopic ossification at the original operated segment. Upper segment degeneration was present in four cases and lower segment degeneration was present in five cases. Further studies are warranted documenting the different types of degeneration seen at levels adjacent to the artificial disc.

In 2010 Garrido et al. reported the results of their prospective RCT (single site) with 48 month follow-up of subjects who underwent implantation with a Bryan cervical disc (n=21), compared to a control of subjects who underwent ACDF (n=26). These same patients were involved in the multicenter IDE trial for the Bryan disc. This data analysis reveals the four year data results of a single center. All patients had single level cervical disc disease (C3 to C7) and radiculopathy or myelopathy and failed nonoperative management for at least six weeks. Clinical outcome tools included NDI, arm pain score (VAS), neck pain score (VAS), and both SF-36 physical and mental component scores. Functional outcomes were evaluated at four years. Both groups showed improvement in NDI scores compare to preoperative values; at 48 months the Bryan group (n=18) had an 80% decrease from preoperative compared to 69% in the control group (n=20). The results for neck pain scores also improved in both groups, 82% in the Bryan group compared with 67% in the control group. The data suggest an 86% decrease in arm pain in the Bryan group compared to 73% decrease in the control group at 48 months. Improvements in SF-36 physical scores improved in both groups and were comparable. SF-36 mental scores revealed improvement with a 24% improvement at four years in the Bryan group compared with 13% in the control group. Six reoperations were performed in the control group and one in the Bryan group. At this institution 48 month follow-up for the Bryan cervical disc continued to compare favorably to ACDF (Garrido, et al., 2010).

In 2010 Goffin et al. published four and six year results of 98 subjects who underwent single or two level disc replacement using the Bryan disc prosthesis. The patient populations arose from two separate studies; a Phase I trial sponsored by Medtronic which involved 54 subjects and patient outcomes up to two years, and a Phase II study which involved an additional 48 subjects with patient outcomes beyond two years and extending to 10 years postoperatively. The subjects in the Phase I study were combined with the Phase II study group. Patients who received the Bryan disc in both studies had either radiculopathy or myelopathy associated with spondylosis and/or disc herniation that did not respond to conservative treatment. Clinical measurements included NDI, SF-36, numerical neck and arm pain scores, neurological outcomes and ODOM classification in addition to radiographs, adverse events and second surgeries. According to the authors outcomes at four and six years were consistent with previously reported results at one and two years. Angular motion for single level was 7.3 and 7.7° at four and six years respectively; angular motion at two level was 5.7 and 6.0° respectively. Only six subjects had adverse events related either possibly or definitely to the Bryan disc, these included migration, device removal, hoarseness and vocal cord paralysis, as well as three cases involving pain and neurological symptoms. Eight underwent further neck surgery to treat symptoms. Postoperative SF-36 values, NDI scores and neck and arm pain scores were better postoperatively when compared to preoperative values. For single level patients the overall neurological success exceeded 83% at all postoperative time periods, except the four year period when it dropped to 72%. At six years it rebounded to more than 88%. A similar trend was seen in the two level group. The authors acknowledged difference in patient assessments between studies and general outcome measures, however at four and six year follow-up clinical outcomes and angular motion was similar to outcomes previously reported at one and two years (Goffin, et al., 2010).

**Literature Review—Multilevel versus Single- Level Cervical:** Pimenta et al. (2007) compared single-level cervical disc replacement utilizing the Porous Coated Motion (PCM) Device to multilevel disc replacement in a consecutive series of 140 patients. A total of 71 patients had single-level replacement and 69 patients had multilevel replacement (53 double, 12 three-level, four four-level). A total of 19 cases were complex revision cases and 21 had adjacent segment disease following cervical fusion. Estimated blood loss, length of hospital stay and length of surgery were greater for the multilevel group. Self assessment outcome instruments (i.e., NDI, VAS scores) demonstrated more improvement for multilevel cases. The mean improvement in the NDI for single cases was 37.6% compared to 52.6% for the multilevel cases; the difference was statistically significant

( $p=0.021$ ). The mean improvement in VAS score was similar, 58.4% for single-level cases versus 65.9% for multilevel cases. The Treatment Intensity Score and Odom's criteria were also more improved for multilevel cases when compared to single-level. Reoperation and adverse events were similar between groups. Using Kaplan–Meier analysis implant survivorship for the overall group was 94.5% at three years. The results of this study suggest a greater clinical outcome improvement for multilevel disc replacement, although the authors note further analysis is necessary.

Cheng and associates (2009) published the results of prospective randomized controlled clinical trial comparing the functional results and radiographic outcomes of fusion ( $n=34$ ) and BRYAN cervical disc replacement ( $n=31$ ) as treatment for two-level cervical disc disease. Evaluation was conducted using the VAS scale, SF-36 and NDI during a two-year follow-up period. Three patients were lost to follow-up. The results demonstrated significant improvement in outcome measures at 24 months, including arm pain VAS, neck pain VAS, NDI, and SF-36 physical scores. While both groups showed statistically significant improvement at two years compared to preoperative scores, the BRYAN group showed better clinical outcomes in comparison to the fusion group. The results to this study are limited by a small sample population and short term outcomes and long-term outcome data is needed to support improvement in health outcomes when used for treatment of two-level disease.

Barbagallo et al. (2009) reported the early results of a surgical technique that combined cervical fusion and disc replacement for treating multilevel DDD ( $n=24$ ). Disc prostheses were implanted at either the level above or below the one receiving a cage as part of the fusion. In some cases two prostheses were implanted and in others two cages were implanted. Average follow-up was 23.8 months. In all but one patient clinical follow-up demonstrated significant improvement; radiological evaluation demonstrated functioning disc prostheses and fusion through cages. While the surgical approach seemed a safe and valid option for patients with multilevel symptomatic cervical DDD, long-term follow-up with larger patient populations are needed to support the clinical effectiveness of this approach.

**Other Cervical Prostheses:** Several additional devices are under development and clinical study for possible use in the treatment of degeneration within the cervical spine. None of these devices are approved by the FDA. Some of these devices include (this list may not be all-inclusive):

- Cervicore™ (Stryker Spine, Summit, NJ)
- Flexicore™ Cervical Disc Replacement (SpineCore-Stryker Spine, Summit, NJ)
- Kineflex/C™ (SpineMotion, Inc., Mountain View, CA)
- Mobi-C® (LDR Spine, Austin, TX)
- Porous Coated Motion (PCM)® (Cervitech, Inc., Rockaway, NJ)
- Secure®-C (Globus Medical, Audobon, PA)

**Cervical Technology Assessments/Guidelines:** NICE published guidance in 2005 on prosthetic intervertebral disc replacement in the cervical spine and considered the device safe and effective for use in the National Health System (NHS). The evidence reviewed included clinical trials evaluating the BRYAN cervical disc, Prestige I and Prestige II cervical discs and consisted of two RCTs and three case series. NICE recommended patients understand that long-term uncertainties remain regarding the procedure (NICE, 2005).

An updated version to the 2007 BCBSA TEC report regarding artificial cervical disc replacement as a proposed treatment for DDD of the cervical spine was published August 2009 (BCBSA, 2009). The assessment focused on data from randomized controlled trials for the Prestige ST and ProDisc-C intervertebral disc, non-FDA approved and precursor devices were excluded. Data for the BRYAN disc which was FDA approved May 2009 was included in the index of the TEC report and did not change the conclusions of the assessment. The report indicates that although informative, the evidence is not sufficient to allow concluding whether artificial intervertebral disc arthroplasty with either device is as beneficial as anterior cervical discectomy and fusion (ACDF) because of uncertainty regarding longer-term outcomes. Furthermore, experience with ACDF and its high success rate requires a convincing rationale and supporting evidence to utilize a different procedure—noninferiority alone is insufficient. Neither trial provides adequate direct evidence over a relevant follow-up period (suggested to be 5 to 7 years) on subsequent adjacent-level DDD in control and investigational group patients. BCBSA TEC concluded artificial intervertebral disc arthroplasty did not meet TEC criteria.

The ECRI Institute reported their findings on intervertebral cervical disc replacement prostheses in an Emerging Technology Evidence Report (ECRI, 2009b). ECRI identified six randomized controlled trials that met their inclusion criteria to address key questions. Common study exclusion criteria were multilevel disease, evidence of cervical instability, previous surgery at the involved level, systemic disease, and chronic disease requiring long-term steroid use. Limitations of the evidence base included lack of long-term outcomes, difficulty estimating adverse event rates, differences in design and materials, potential conflict of interest, and moderate attrition. Based on their review of the evidence ECRI concluded that the limited data currently available suggest that cervical AIDR may be as effective as cervical fusion for relieving pain and improving function in the short-term (one to two years). While adverse events were reported in both AIDR and fusion groups in all the studies assessed, determining specific adverse event rates associated with cervical AIDR was not possible. Long-term follow-up data on larger numbers of patients are needed to assess the long-term durability of artificial cervical discs.

California Technology Assessment Forum (CTAF) published a technology assessment of artificial disc replacement for degenerative disc disease of the cervical spine (CTAF, 2009). According to the report the evidence evaluating the long term clinical impact of artificial cervical disc replacement is lacking, consequently whether or not the technology ultimately improves net health outcomes is not known; it is not known whether or not the technology is as beneficial as the established alternatives, and whether or not an improvement in long term clinical outcomes is attainable outside the investigational is unknown due to lack of long-term evidence. Cervical disc replacement as an alternative to anterior fusion did not meet TEC criteria.

Although it is not an official position statement, in 2010 the American Academy of Orthopaedic Surgeons (AAOS) published a technology overview of cervical disc arthroplasty. The overview was based on the findings of studies published prior to September 2009. The committee addressed four key questions regarding the technology, comparing the outcomes of patients treated with cervical IVD replacement to patients treated with ACDF. The key questions addressed what patient characteristics predicted successful outcomes in patients who underwent cervical IVD replacement compared to ACDF; do patients with herniated disc and arm pain, with or without neck pain, have equal or better outcomes when compared to ACDF, are the revision rates and/or complication rates equal or better in those who receive disc replacement compared to ACDF, and for patients which is more economical, according to hospital length of stay and return to work. Regarding patient characteristics, the data was inconclusive, most studies did not report a statistical analysis, and only one level II study reported no statistically significant difference. For clinical outcomes, five level II studies were included. There was a trend for better NDI scores and NDI success rate at early follow-up, data for long term follow-up was inconclusive. While one study reported arthroplasty had significantly higher neurologic success rates, two level II studies reported no statistically significant differences. A majority of the studies reported no statistically significant difference in either neck or arm pain scores at short term follow-up (six months to 24 months), long term data was inconclusive. The result reported by three level II studies was inconclusive regarding SF-36 scores and there were no differences in the number of patients who returned to work at 24 months. The results of four level II studies were included, three did not report secondary surgery results similarly, and therefore the results could not be compared. The results for adverse events were also inconclusive in these same studies. Patients who underwent arthroplasty returned to work in significantly fewer days although the length of hospital stay did not vary between groups.

**Summary Cervical Intervertebral Disc Prostheses:** When measuring safety and efficacy outcomes at 24 months of follow-up, three cervical artificial discs have been determined to be noninferior to anterior cervical discectomy and fusion. As part of the FDA post approval process, one recently published clinical study supports noninferiority at five years post cervical disc insertion for the portion of subjects who have completed a 60 month evaluation at this time. The current evidence suggests that cervical disc replacement offers some advantages over cervical fusion in the short-term (one to two years), with some data supporting long-term advantages (five years). Improvement in clinical outcomes such as neck pain, disability scores and neurological status as well as more rapid return to work has been reported. Comparison across studies is confounded by variables such as differences in device design and materials and there is a lack of long term data evaluating device performance, durability, revision rate, and functional clinical outcomes. The post-surgical affect on adjacent spinal segments is not yet determined and requires further investigation. Moreover, the FDA mandated post-approval studies have not been completed at this time. Additional data concerning the use of these devices is required before long-term patient safety, net health outcomes and device durability can be determined.

## Partial Disc Replacements

As an alternative to the complete replacement of both an injured or diseased disc, researchers are also exploring the possibility of performing a partial disc replacement, also referred to as a nucleus arthroplasty. With this procedure only the nucleus of the disc is replaced; theoretically the annulus and endplates function properly. Nucleus arthroplasty devices are in the earliest stages of development and study. Examples include, but are not limited to: the Prosthetic Disc Nucleus PDN (Raymedica, Inc., Bloomington, MN); NeuDisc (Replication Medical, Inc., New Brunswick, NJ); and the Newcleus (Zimmer Spine, Warsaw, IN) (Bertagnoli, 2005). The devices may be classified as hydrogel, polymer/synthetic or mechanical technologies. Until approval can be obtained through the FDA, and clinical trials are conducted that provide guidance on specific patient selection, or patient net health outcomes, the use of these devices for the treatment of DDD remains investigational.

## Professional Societies/Organizations

At the present time, no professional societies or organizations have published a position statement or evidence-based clinical practice guidelines regarding the use of intervertebral lumbar disc prostheses.

The International Society for the Advancement of Spine Surgery (ISASS) published a position statement December 2009 for cervical disc arthroplasty. The position of ISASS is as follows: "Total disc arthroplasty (TDA) is an acceptable, proven alternative to anterior cervical discectomy and fusion (ACDF) in the treatment of symptomatic cervical disc disease (CDD) for the indications, as described in the FDA approvals. Even at the relatively early 2 year post-operative time point, several high quality studies have shown significantly lower re-operation rates after TDA when compared to ACDF" (ISASS, 2009).

## Summary

Evidence in the published, peer-reviewed scientific literature has demonstrated that the use of the Charité and ProDisc®-L intervertebral disc prostheses can be safely implanted and effective in the treatment of degenerative disc disease in a select group of individuals. While the long-term safety and efficacy of these devices will continue to be monitored, the short-term results have shown that these devices can improve the maintenance of range of motion within the lumbar spine and provide stabilization to the intervertebral disc space. Postsurgical study results have also shown that use of the disc prostheses can reduce pain, while improving disability scores.

The safety and efficacy of other lumbar intervertebral disc prostheses have yet to be determined. FDA approval for the use of intervertebral disc prostheses other than the Charité and ProDisc®-L has not been obtained.

There are insufficient long-term clinical trial data in the published, peer-reviewed literature to support the use of cervical intervertebral prostheses for the treatment of intractable radiculopathy and/or myelopathy. The long-term safety and efficacy of the Prestige ST Cervical Disc System, ProDisc-C, or BRYAN cervical disc has yet to be determined. There are several cervical devices undergoing various stages of study and clinical review; however, the use of cervical intervertebral discs remains investigational due to the paucity of data concerning their long-term use.

The safety and efficacy of partial disc(s) replacement systems (i.e., nucleus arthroplasty) cannot be determined at this time, due to the lack of FDA approval for the devices and the lack of clinical trial evidence within the published literature.

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## Coding/Billing Information

**Note:** This list of codes may not be all-inclusive.

**Covered when medically necessary:**

CPT®* Codes	Description
22857†	Total disc arthroplasty (artificial disc), anterior approach, including discectomy to prepare interspace (other than for decompression), single interspace, lumbar

<sup>†</sup>**Note:** Covered when used to report the surgical implantation of a Charité or ProDisc®-L prosthesis and medical necessity criteria outlined in this Coverage Policy are met.

ICD-9-CM Diagnosis Codes	Description
722.52	Degeneration of lumbar or lumbosacral intervertebral disc
722.73	Intervertebral disc disorder with myelopathy, lumbar

**Experimental/Investigational/Unproven/Not Covered:**

**Lumbar Disc Replacement**

CPT* Codes	Description
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)

ICD-9-CM Diagnosis Codes	Description
	All Codes

**Cervical Disc Replacement**

CPT* Codes	Description
22856	Total disc arthroplasty (artificial disc), anterior approach, including discectomy with end plate preparation (includes osteophyctomy for nerve root or spinal cord decompression and microdissection), single interspace, cervical
0092T	Total disc arthroplasty (artificial disc), anterior approach, including discectomy with end plate preparation (includes osteophyctomy for nerve root or spinal cord decompression and microdissection), each additional interspace, cervical (List separately in addition to code for primary procedure)

ICD-9-CM Diagnosis Codes	Description
722.4	Degeneration of cervical intervertebral disc
722.71	Intervertebral disc disorder with myelopathy, cervical
722.91	Other unspecified disc disorder, cervical
	All Codes

\*Current Procedural Terminology (CPT®) © 2010 American Medical Association: Chicago, IL.

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## Policy History

<b>Pre-Merger Organizations</b>	<b>Last Review Date</b>	<b>Policy Number</b>	<b>Title</b>
CIGNA HealthCare	12/15/2007	0104	Intervertebral Disc (IVD) Prostheses
Great-West Healthcare	11/30/2007	04.266.04	Intervertebral Disc Prosthesis

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Connecticut General Life Insurance Company has acquired the business of Great-West Healthcare from Great-West Life & Annuity Insurance Company (GWLA). Certain products continue to be provided by GWLA (Life, Accident and Disability, and Excess Loss). GWLA is not licensed to do business in New York. In New York, these products are sold by GWLA's subsidiary, First Great-West Life & Annuity Insurance Company, White Plains, N.Y.