TOTAL ARTIFICIAL DISC REPLACEMENT FOR THE SPINE

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INSTRUCTIONS FOR USE

This Medical Policy provides assistance in interpreting UnitedHealthcare benefit plans. When deciding coverage, the member specific benefit plan document must be referenced. The terms of the member specific benefit plan document [e.g., Certificate of Coverage (COC), Schedule of Benefits (SOB), and/or Summary Plan Description (SPD)] may differ greatly from the standard benefit plan upon which this Medical Policy is based. In the event of a conflict, the member specific benefit plan document supersedes this Medical Policy. All reviewers must first identify member eligibility, any federal or state regulatory requirements, and the member specific benefit plan coverage prior to use of this Medical Policy. Other Policies and Coverage Determination Guidelines may apply. UnitedHealthcare reserves the right, in its sole discretion, to modify its Policies and Guidelines as necessary. This Medical Policy is provided for informational purposes. It does not constitute medical advice.

UnitedHealthcare may also use tools developed by third parties, such as the MCG™ Care Guidelines, to assist us in administering health benefits. The MCG™ Care Guidelines are intended to be used in connection with the independent professional medical judgment of a qualified health care provider and do not constitute the practice of medicine or medical advice.

BENEFIT CONSIDERATIONS

Before using this policy, please check the member specific benefit plan document and any federal or state mandates, if applicable.

Essential Health Benefits for Individual and Small Group

For plan years beginning on or after January 1, 2014, the Affordable Care Act of 2010 (ACA) requires fully insured non-grandfathered individual and small group plans (inside and outside of Exchanges) to provide coverage for ten categories of Essential Health Benefits ("EHBs"). Large group plans (both self-funded and fully insured), and small group ASO plans, are not subject to the requirement to offer coverage for EHBs. However, if such plans choose to provide coverage for benefits which are deemed EHBs, the ACA requires all dollar limits on those benefits to be removed on all Grandfathered and Non-Grandfathered plans. The determination of which benefits constitute EHBs is made on a state by state basis. As such, when using this policy, it is important to refer to the member specific benefit document to determine benefit coverage.

COVERAGE RATIONALE

Cervical artificial total disc replacement of FDA-approved prosthesis for degenerative cervical disc disease with symptomatic intractable radiculopathy and/or myelopathy is proven and medically necessary in a skeletally mature individual when at least one of the following criteria is met:

- herniated disc
- osteophyte formation

And both of the following:
- documented patient history of neck and/or arm pain and/or a functional/neurological deficit associated with the cervical level to be treated
- failed at least six weeks of non-operative treatment prior to implantation (only applicable for elective surgery; emergent surgery, or does not require prior non-operative treatment)

**Cervical artificial disc replacement is proven and medically necessary for treating symptoms of degenerative disc disease at one level even if they have radiological evidence of degenerative disc disease at multiple levels.**
Radiologic evidence of degenerative disc disease is common in persons who are middle aged and older and does not necessarily correlate with clinical symptoms.

**Cervical artificial total disc replacement is proven and medically necessary for treating symptomatic contiguous two level degenerative disc disease in skeletally mature patients when used according to U.S. Food and Drug Administration (FDA) labeled indications.**

**Note:** not all cervical artificial discs have FDA labeling for contiguous two level degenerative disc disease. Only cervical artificial discs FDA labeled for contiguous two level disease are proven and medically necessary for this indication. Refer to the [FDA](https://www.fda.gov) section below.

**Cervical artificial disc replacement at one level combined with cervical spinal fusion surgery at another level (adjacent or non-adjacent) performed at the same surgical setting is unproven and not medically necessary.**
This is commonly referred to as a hybrid surgery. There is insufficient published clinical evidence in peer-reviewed medical literature demonstrating the safety and efficacy of combination cervical spine surgery at multiple adjacent or non-adjacent levels.

**Lumbar artificial total disc replacement is unproven and not medically necessary for treating single or multiple level degenerative disc disease in skeletally mature patients.**
The long-term clinical outcome of lumbar disc replacement is unclear. The evidence from uncontrolled long-term studies suggests that potential degeneration of adjacent discs and facets and wear of the polyethylene part of the disc may occur and that, in some cases, revision surgery may be needed.

**APPLICABLE CODES**

The following list(s) of procedure and/or diagnosis codes is provided for reference purposes only and may not be all inclusive. Listing of a code in this policy does not imply that the service described by the code is a covered or non-covered health service. Benefit coverage for health services is determined by the member specific benefit plan document and applicable laws that may require coverage for a specific service. The inclusion of a code does not imply any right to reimbursement or guarantee claim payment. Other Policies and Coverage Determination Guidelines may apply.

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Artificial total disc replacement refers to the replacement of a degenerating intervertebral disc with an artificial disc in adults with degenerative disc disease (DDD) in either the lumbar or cervical region of the spine. An artificial disc is intended to preserve range of motion (ROM) and reduce pain (ECRI, 2009). 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 pain.

Artificial discs may consist of two cobalt-chromium endplates that are attached to the vertebrae and a polyethylene disk that is inserted between the metal endplates may be metal on metal, metal on plastic, ceramic on ceramic or titanium on polyurethane. Discs are implanted through an anterior approach and are attached to vertebrae with screws, teeth, ridges, or pins.

### Clinical Evidence

#### Cervical Artificial Disc (Single Level)

Cervical intervertebral disc prostheses that have been approved by the FDA for surgical implantation within the spine, for single-level cervical disc replacement include but are not limited to The Prestige® ST Cervical Disc (Medtronic Sofamor Danek, Memphis, TN), the PRODISC-C® Total Disc Replacement (Synthes, Inc., New York, NY) and the BRYAN® Cervical Disc (Medtronic Sofamor Danek, Memphis, TN), SECURE®-C Artificial Cervical Disc (Globus Medical Inc., Audubon, PA), and Mobi-C® Cervical Disc (LDS Spine USA, Inc. Austin, TX).

Bakar et al (2014) concluded that “Given the long-term outcomes that have been studied for anterior cervical discectomy and fusion, it is difficult to assess the future potential of anterior cervical disc arthroplasty as an alternative to anterior cervical discectomy and fusion. It is important to note that current studies with follow-up to 4 years have shown promising outcomes. The ability of anterior cervical disc arthroplasty to decrease the potential for common and well-known late complications of anterior cervical disectomy and fusion (such as adjacent segment disease) is an important and interesting possibility. Future long-term randomized controlled trials and cost effectiveness studies are needed to properly assess the continued use of artificial cervical disc arthroplasty and to determine the relative cost effectiveness compared with anterior cervical discectomy and fusion.”

Jawahar et al. (2010) compared the incidence of adjacent segment disease in 93 patients who were randomized to receive artificial disc (n=59) or anterior cervical discectomy and fusion (n=34). The study was part of 3 different United States Food and Drug Administration (FDA) prospective randomized controlled Investigational Device Exemption (IDE) trials involving 3 different artificial discs (Kineflex-C, Mobi-C and AdventCervical) at their institution. Visual analog pain score (VAS), Neck Disability Index (NDI), and cervical spine radiographs were collected at 6 weeks and at 3 and 6 months, and then annually up to 4 years after their surgery. At median follow-up of 36.4 months (range, 24-49 months), 65 patients were free from symptoms. In the remaining 28 patients, surgery was not successful. The success rates for artificial disc (71%) were not statistically different from those of fusion (73.5%). The actuarial median symptom-free survival period was not significantly different. The final scores for VAS and NDI were similar for both groups. Eighteen percent of artificial disc patients and 15% fusion patients developed adjacent segment degeneration. Concurrent lumbar DDD significantly increased the risk of adjacent segment degeneration. The authors only reported positive outcomes and did not report the incidence or rate of revision or account for those patients in whom surgery was not successful. Although artificial disc affords a significantly quicker symptomatic relief, the longer-term outcomes do not prove results superior to those with fusion. The authors concluded that artificial disc is equivalent to fusion for providing relief from symptoms in the treatment of one- and two-level DDD of cervical spine. Additionally, the risk of developing adjacent segment degeneration is equivalent after both procedures but is significantly higher in patients with concurrent DDD in lumbar spine. The authors only reported positive outcomes and

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*CPT® is a registered trademark of the American Medical Association*
did not report the incidence or rate of revision. Artificial disc appears to be equivalent to anterior cervical discectomy and fusion.

Huppert et al. (2011) conducted a prospective multicenter study to compare the clinical and radiological outcomes of cervical disc replacement between single- (n=175) and multilevel (n=56) patients receiving the Mobi-C® device. Follow-up (FU) evaluation was performed at 1, 3, 6, 12, and 24 months after surgery. Comparison between both groups was based on Neck Disability Index (NDI), Visual Analog Scale (VAS), and Range of Motion. At 24 months, mean NDI and VAS scores for neck and arm pain were improved in both groups similarly. Improvement in range of motion was also similar with the single level group having an increase of 2.8 degrees compared to 2.2 degrees in the multilevel group. Post-operative analgesic use was higher in the multilevel group at 53% compared to 32% for the single level group. Complications occurred in 19 of the 175 (10.9%) single level patients compared to 11 in the 56 (19.6%) multilevel patients. The rate of dysphagia/dysphonia was significantly higher in the multi-level group (9/56 or 16%) versus (6/175 or 3.4%) in the single-level group. Four patients in the single level group underwent a secondary surgery (2 fusions; 2 disc replacement) versus 2 patients in the multilevel group that had a third device implanted. There were no significant differences between the groups however additional studies are needed to evaluate the impact on safety and efficacy for multilevel disc replacement.

Cheng and associates (2009) published the results of BRYAN cervical disc replacement 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. 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.

A prospective study by Phillips et al. (2009) evaluated outcomes of cervical disc replacement performed in patients with and without previous anterior cervical decompression and fusion (ACDF) receiving the porous coated motion (PCM) artificial cervical disc in a United States Federal Drug Administration Investigational Device Exemption trial. One hundred fifty two patients were enrolled in the study; 126 patients without previous ACDF and 26 patients with a previous "adjacent level" fusion surgery. Postoperative follow-up occurred at 6-weeks, 3-month, 6-month, 1-year, and 2-years. At 1 year, 93 of the 126 patients with no prior surgery and 21 of 26 prior surgery patients completed follow-up. Outcomes were measured using the Neck Disability Index and Visual Analog Scores which showed improvement after surgery and were similar between groups at all time points. Revision surgery occurred in 2 of 126 primary patients, and in 2 of 26 patients in the adjacent-to-fusion group. The authors found that while both groups had similar outcomes, additional long-term studies are needed to evaluate complication rates as well as whether outcomes are maintained over time.

**Pro-Disc C**

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 plate providing an 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.

Zigler et al. (2012) published interim five year clinical outcomes of the patient cohorts in the original noninferiority FDA IDE trial comparing cervical arthroplasty using ProDisc-C to anterior cervical discectomy and fusion (ACDF). This study is an interim report to the seven year post-approval study. The FDA IDE study involved 209 subjects from 13 sites. All clinical outcomes improved at both two and five years compared to baseline with a statistically significant difference in scores. There was no percent change between groups for neck pain intensity and frequency at two years but there was a difference at five years. Though both groups had statistically significant reduction of neck pain intensity and frequency at five years compared to baseline, the reduction was more significant in the Pro-Disc group. Though both groups had statistically significant reduction of neck pain intensity and frequency at five years compared to baseline, the reduction was more significant in the Pro-Disc group. Both groups had statistical improvement in nearly all areas and both groups were very satisfied with thei

Kelly et al. (2011) compared adjacent segment motion following disc arthroplasty using the ProDisc-C device versus anterior cervical discectomy and fusion (ACDF) in 209 patients in a prospective randomized controlled trial at 13 sites. The authors reported no significant difference in adjacent segment range of motion (ROM) was observed between ACDF and TDA. Only time was a significant predictor of postoperative ROM at both the cranial and caudal adjacent segments. The ROM decreased over time with fusion whereas disc replacement results in immediate motion sustained throughout the follow-up period.
Nabhan et al. (2007) conducted a prospective, randomized controlled study of 25 patients to analyze and compare segmental motion in patients receiving Pro-Disc C or standard cervical disc fusion. Patients were randomized into the 2 groups. Radiostereometric analysis was used to quantify intervertebral motion. Results were judged using visual analogue scale and neuro-examination. Cervical spine segmental motion decreased over time in both groups; however, the loss of segmental motion was significantly higher in the cervical disc fusion group. Neck and shoulder pain decreased in both groups however the difference was insignificant. Follow-up at 6 months showed that cervical spine motion was present in both study groups, but less motion was detected in patients who underwent a cervical discectomy with fusion and instrumentation.

In a prospective, randomized, controlled trial by Murrey et al. (2009), 209 patients (106 cervical disc fusions; 103 ProDisc-C) were randomized and treated to compare the safety and efficacy of cervical disc replacement with ProDisc-C to anterior cervical discotomy and fusion (ACDF) surgery. Patients were enrolled and treated in accordance with the US Food and Drug Administration (FDA)-approved protocol. Patients were assessed pre- and postoperatively at six weeks, 3, 6, 12, 18, and 24 months. Outcomes were measured utilizing visual analog scale (VAS) pain and intensity (neck and arm), VAS satisfaction, neck disability index (NDI), neurological exam, device success, adverse event occurrence, and short form-36 (SF-36) standardized questionnaires. Both groups showed equal results post-operatively in clinical outcomes. Therefore, the authors concluded that ProDisc-C implantation was either equivalent or superior to the clinical outcomes seen after fusion.

Delamarter et al. (2010) presented the preliminary 4 year follow-up results of the Murrey IDE study. The follow-up rates at 48 months for ProDisc-C TDR and ACDF were 63.0% and 46.2%, respectively, at the time of publication. After closure of randomized enrollment an additional group of 136 continued access (CA) patients had ProDisc-C TDR surgery. At 24 months, there was no significant difference in neurologic improvement among the 3 groups. At 48 months, the overall neurologic improvement trended toward significance for ProDisc-C TDR patients compared with ACDF patients. VAS scores decreased at 24 months in all 3 groups. At 48 months the ACDF group showed only a 38.7 mm reduction in mean VAS score from preoperative levels compared with 49.3 mm in the ProDisc-C TDR group, although this difference was not statistically significant. On radiographic exam at 24 months, flexion-extension range of motion (ROM) at the index level was similar between the Pro-Disc-C TDR and the CA group (9.38° and 9.50°). ROM was <2° in 91.2% of the ACDF patients at 24 months. At 48 months, flexion-extension ROM was maintained in Pro-Disc-C TDR group (9.12°), and 95.5% of the ACDF group had <2°ROM. Of the original study participants, (103 ProDisc and 106 ACDF), 11 patients (2 Pro-Disc C and 9 ACDF) required secondary surgical procedures by 24 months. The 3 Pro-Disc patients converted to fusion. In the ACDF group, 6 underwent additional fusion at both the index and adjacent levels, 1 had a revision due to dysphagia associated with plate liftoff, and 1 had posterior decompression with supplemental fixation. By 48 months, 3 of Pro-Disc-C TDR patients and 12 of ACDF patients had required a secondary surgical procedure. The authors conclude that preliminary data at 4 years shows that both total disc replacement and ACDF are viable surgical options for patients with symptomatic cervical disk disease.

**Prestige**

Evidence in the peer-reviewed published scientific literature evaluating early models of the PRESTIGE cervical disc included case series with few randomized trials.

The PRESTIGE 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. As part of approval, the FDA is requiring a seven-year post-approval study to evaluate long-term safety and effectiveness of the Prestige ST Cervical Disc.

Early results from a prospective, randomized controlled trial of 55 patients comparing the efficacy and safety of treatment with the Prestige II artificial disc with anterior cervical fusion were reported by Porchet (2004). Outcomes at 1 year for 37 patients and at 2 years for 9 patients suggest that artificial cervical disc replacement with the Prestige II is comparable to or better than fusion in relieving pain and other cervical degenerative disc disease symptoms while preserving motion at the treated disc level. In those patients receiving fusion, 19 adverse events were reported, and in those patients receiving artificial disc replacement, 17 adverse events were reported. Adverse events associated with the Prestige II disc included residual neck and shoulder pain, transient recurrent palsy, and temporary dysphagia. In March 2007, Mummaneni et al. published the results of the pivotal FDA Investigational Device Exemption (IDE) trial that led to approval of the device in July 2007. In this manufacturer-sponsored, prospective randomized multicenter study, 541 patients with single-level intractable cervical DDD were randomized into 2 treatment groups: 276 patients who received the Prestige ST cervical Disc System and 265 patients underwent decompressive anterior cervical disc fusion with allograft and plate fixation. Eighty percent of the arthroplasty-treated patients (223 of 276) and 75% of the control patients (198 of 265) completed clinical and radiographic follow-up examinations at routine intervals for 2 years after surgery. Comparison between the groups showed the Prestige ST group had greater relief of neck pain, returned to work sooner, and had a less adjacent-segment re-operation than the cervical disc fusion group. There were no revision surgeries in the Prestige group, but the control group had 5 revision surgeries. Implant removal was necessary in both treatment groups (1.8% for the Prestige group vs. 3.4% for the control group). Reoperations were required for adjacent-segment disease in both treatment groups (3 in the Prestige group vs. 11 in the control...
The cervical disc implant group maintained an average of 7 degrees in segmental sagittal angular motion. The study is limited by manufacturer sponsorship and short term follow-up. Additional studies are needed to establish long-term efficacy and impact of implant on adjacent discs.

Burkus et al. (2010) presented 5 year follow-up results of the 2007 Mummaneni manufacturer-sponsored study. Of the 541 patients in the study, 271 (144 investigational and 127 control patients) completed 5 years of follow-up. Mean preoperative Neck Disability Index (NDI) scores for the investigational group were 55.7 and 56.4 for the control group. NDI scores at both 36 and 60 months improved an average of 36.3 and 38.4 points in the investigational group and 31.3 and 34.1 points for the control group. Neck pain and arm pain scores had similar improvements at both 35 and 60 months. Maintenance or improvement of neurological status was seen in both groups, at both 36 and 60 months with greater improvement seen in the investigational group (92.8% and 95%) compared to the control group (83.2% and 88.9%). Angular motion of the Prestige disc averaged more than 7.3o at 36 months and 6.5o at 60 months. At 24 months, there were no revision surgeries in the investigational group compared to 5 revision procedures in the control group. The investigational group had a lower incidence of supplemental fixation than the control group (0.0% vs. 3.4%). Surgery for adjacent level disease trended lower in the investigational group (11 surgeries in 8 patients) compared to the control group (16 surgeries in 13 patients). The authors concluded that cervical disc arthroplasty has the potential to preserve neck motion while providing stability and mobility as demonstrated by these 5 year outcomes.

**Bryan**

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 has 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 vertebral or fixation by use of stabilizing keels.

Quan et al (2011) evaluated the long-term outcome of cervical disc arthroplasty. Clinical and radiological data were obtained from the 8-year post-operative review. The authors concluded that at 8-year follow-up, the Bryan cervical disc arthroplasty maintains favorable clinical and radiological results, with preservation of movement and satisfactory clinical outcome in the majority of cases. However, the incidence of heterotopic ossification causing restricted range of movement of the prosthesis appears to increase with time, especially in bi-level procedures.

A prospective, randomized, multicenter study by Heller et al. (2009) was conducted on 463 patients to compare the BRYAN cervical disc arthroplasty with anterior cervical decompression and fusion. Patients were divided into 2 groups: 242 received the investigational device (Bryan Cervical Disc), and 221 patients underwent a single-level anterior cervical discectomy and decompression and fusion as a control group. Patients completed clinical and radiographic follow-up examinations at regular intervals for 2 years after surgery. Analysis of 12- and 24-month postoperative data showed improvement in all clinical outcome measures for both groups; however, 24 months after surgery, the investigational group patients treated with the artificial disc had a statistically greater improvement in the primary outcome variables: Neck disability index score and overall success. With regard to implant- or implant/surgical-procedure-associated serious adverse events, the investigational group had a rate of 1.7% and the control group, 3.2%. Patients who received the artificial cervical disc returned to work nearly 2 weeks earlier than the fusion patients. The authors concluded that cervical disc arthroplasty is a viable alternative to anterior cervical discectomy and fusion in patients with persistently symptomatic, single-level cervical disc disease. However, failure rate and conversion to fusion were not reported.

Sasso and colleagues (2011) reported 48 month follow-up data to the pivotal FDA clinical trial published by Heller et al (2009). Of the original 463 subjects who were enrolled in the FDA trial, 24 month results for 424 subjects in total have been previously reported. A condition for approval of the device from the FDA was an extension of the original trial to 10 years post surgery. The results reported by Sasso et al. (2011) reflect a total of 319 subjects (181 arthroplasty, 138 fusions) who were available for follow-up at 48 months. (The authors reported that at 48 months greater improvement in NDI scores, arm pain scores. Neurological success rates at 48 months were similar to those reported at 24 month and were not significantly different. At 48 months more TDR subjects returned to work compared to the fusion group, although not significantly different. Mean cervical spine motion increased for the disc group at all time points whereas the fusion group showed a decrease of motion at 48 months. Forty-four subjects in the arthroplasty group had 63 adverse events while 36 of the subjects in the fusion group had 64 adverse events; the difference was not significant. The authors noted most of the events were unrelated to the index surgery or cervical spine. Despite the limitation of a low rate of follow-up, which the authors attribute to the original design of the study (set for 24 months), the authors concluded significantly superior outcomes were sustained for cervical spinal arthroplasty with the Bryan disc compared to fusion at 48 month follow-up.
Coric et al. (2006) reported on the safety and efficacy of the Bryan cervical artificial disc compared to fusion in 33 patients with single-level DDD based on data obtained at a single investigational site of the FDA IDE trial (Heller et al., 2009). At 24 month follow-up, no device-related complications had occurred and patients with the Bryan disc had clinical outcomes similar to the patients who had undergone spinal fusion.

In a prospective, randomized study by Sasso et al. (2007), 115 patients were enrolled to compare the Bryan artificial disc replacement to anterior cervical fusion. This study is a pooled data set from 3 centers involved in the FDA IDE trial (Heller et al., 2009) evaluating the Bryan artificial cervical disc. There were 56 patients in the Bryan group and 59 patients in the fusion group. Patients were followed for 24 months with 99 patients completing the study. Disability and pain were assessed using the Neck Disability Index (NDI) and the Visual Analog Scale (VAS) of the neck and of the arm pain. Range of motion was determined by independent radiologic assessment of flexion-extension radiographs. At 2 year follow-up, NDI for the Bryan group is 11 and the control group is 20 and the average arm pain VAS for the Bryan group was 14 and control 28. The disc replacement group retained an average of 7.9 degrees of flexion-extension at 24 months. There were 6 additional operations in this series: 4 in the cervical fusion and 2 in the artificial disc group. Based on these results, the authors concluded the Bryan artificial disc replacement compares favorably to anterior cervical discectomy and fusion for the treatment of patients with 1-level cervical disc disease. The study is limited by short-term follow-up and subjective outcomes. Additional studies are needed to establish long-term efficacy.

A prospective randomized controlled trial by Garrido et al. (2010) reported 4 year follow-up results 47 patients from the Sasso (2007) study randomly assigned to undergo cervical arthroplasty with the Bryan disc (n=21) or spinal fusion (n=26). Outcomes were measured by neck disability index (NDI) score, visual analog score (VAS) for both neck and arm pain, short form (SF-36) physical and mental scores. At the 4 year follow-up, NDI scores changed from 50 preoperatively in both groups to 10 in the cervical disc group and 16.7 in the fusion group. Preoperative neck pain scores on a visual analog scale (VAS) were 76.2 in the disc group and 80.6 in the fusion group. After four years, neck VAS scores were 13.6 in the disc group and 28.1 in the fusion group. Arm pain VAS scores were 78.8 in the disc group and 77.1 in the fusion group preoperatively. After four years, arm pain VAS scores were 10.8 in the disc group and 21.7 in the fusion group. Results were similar between the 2 groups for the SF-36 physical scores; however, for the SF-36 mental scores, there was a 24% improvement in the disc group compared with 13% in the fusion group at 4 years. A total of 6 patients in the control group and 1 patient in the disc group (total of 7 procedures) required reoperation from the initial procedures. In the control group this included 3 procedures for adjacent-level degenerative disc disease (DDD) and 1 procedure for remote-level DDD which were revised to a fusion, and 2 procedures in 1 patient for pseudarthrosis (failed spinal fusion) that required a facet neurotomy and supplemental fixation. There was 1 procedure for adjacent-level DDD in the disc group that was converted to a fusion. These results appear to show a clinical favorable outcome regarding functional outcomes and adjacent segment disease for cervical disc replacement. Longer term, multicenter studies will be required to definitively prove that cervical arthroplasty does statistically correlate with a lower incidence of adjacent level degeneration and overall better outcomes.

Heidecke et al. (2008) conducted a prospective study of 54 consecutive patients with degenerative cervical disease who underwent ventral discectomy and disc replacement with the Bryan cervical disc prosthesis. A total of 59 prosthetic discs were implanted, in 49 patients at a single level and in 5 at two adjacent levels. Neurological status was evaluated pre-operatively and at one and two years thereafter. Plain X-rays, CT, and MRI were used for pre-operative diagnostics. Post-operative follow-up was done by X-rays. Clinical results and functional outcome at 2 years showed that all patients reported excellent or good neurological outcome. Seven patients experienced loss of mobility, mainly due to the development of heterotopic ossification. Further investigations with longer follow-up periods and with a control group (e.g. fusion with intervertebral cage) will be necessary for a definitive assessment of the long-term functionality and benefits of artificial cervical discs.

Goffin et al. (2010) reported on 4- and 6-year follow-up results after cervical disc replacement surgery using the Bryan Cervical Disc Prosthesis. A total of 98 patients (89 with 1-level and 9 with 2-level implantations) participated in the follow-up studies for up to 10 years postoperatively. Outcomes were measured utilizing the 36-Item Short Form Health Survey, Neck Disability Index, numerical ratings of neck and arm pain, neurological outcomes, Odom classification and angular motion findings from lateral flexion-extension radiographs. The mean angular motion results at 4 and 6 years postoperatively for 1-level patients were 7.3 and 7.7°, respectively. Two-level patients had slightly less motion at 4 and 6 years postoperatively with mean caudal values of 5.7 and 6.0°, respectively, and cephalad values of 4.2 and 6.2°, respectively. A total of 65 patients (61 1-level and 4 2-level patients) had at least 1 adverse event recorded however only 6 of these were judged to be related to the device. These events included device migration, device removal, hoarseness and vocal cord paralysis, as well as 3 cases involving pain and neurological symptoms. In addition, 8 patients underwent further neck surgery to treat symptoms. The authors conclude that favorable outcomes persist after 4-6 years of follow-up. The study was manufacturer sponsored and is limited by small sample size and subjective outcomes.
A study by Walraevens et al. (2010) of the same 89 patients in the Goffin study above assessed the intermediate and long-term radiographic characteristics of disk replacement surgery with the Bryan Cervical Disc. There were no cases of anteroposterior migration or subsidence. Mobility at the treated level was preserved in > or = 85% of cases. The authors concluded that the device maintains preoperative motion at the index and adjacent levels, seems to protect against acceleration of adjacent-level degeneration as seen after anterior cervical discectomy and fusion, and remains securely anchored in the adjacent bone mass in the long run.

**Technology Assessments**

A 2014 Hayes Medical Technology Directory report concludes that the evidence suggests that single level total artificial disc replacement (TDR) is either comparable or superior to ACDF for both clinical (overall success, NDI, neurologic success) and safety outcomes. There is growing evidence that bi-level TDR is generally consistent with ACDF for clinical and safety outcomes in the short term (Updated December 11, 2015).

In September 2012 ECRI Institute published an evidence based report evaluating cervical disc replacement that included evidence published until April 2012. Eleven publications met the inclusion criteria, six were randomized controlled trials and five consisted of case series. The evidence reviewed by ECRI did not permit conclusions regarding rate of occurrence of adverse events.

National Institute for Health and Care Excellence (NICE): In 2010, NICE issued a guidance statement on the use of prosthetic intervertebral disc replacement in the cervical spine. NICE concluded that the current evidence on the efficacy of prosthetic intervertebral disc replacement in the cervical spine shows that this procedure is as least as efficacious as fusion in the short term and may result in a reduced need for revision surgery in the long term. They further state that the evidence raises no particular safety issues that are not already known in relation to fusion procedures.

**Professional Societies**

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 committee addressed four key questions regarding the technology, comparing the outcomes of patients treated with cervical intervertebral disc (IVD) replacement to patients treated with anterior cervical disc fusion (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. The International Society for the Advancement of Spine Surgery (ISASS) published a policy statement (ISASS, 2014) supporting the safety and efficacy of cervical disc arthroplasty as an alternative to anterior cervical discectomy and fusion for individuals with one or two level cervical radiculopathy or myelopathy.

The North American Spine Society (NASS) has revised its formal coverage recommendation for Cervical Artificial Disc Replacement (CADR). The evidence-based coverage policy recommendation now includes support for both one and two-level CADR when clinically indicated (radiculopathy or myelopathy from disc degeneration following appropriate non-operative care). The Coverage Committee states that the "rationale for coverage of CADR is based on the indications and results of many randomized controlled trials (RCTs) that have compared the procedure to what most would consider the gold standard surgical treatment, anterior cervical discectomy and fusion (ACDF)” (Orthopreneur, December 2015).

**Cervical Artificial Disc (Two Level)**

Davis et al. (2013) conducted a prospective, randomized controlled clinical trial (RCT) at 24 centers in the US. The primary objective of this study was to rigorously compare the Mobi-C cervical artificial disc to ACDF for treatment of cervical DDD at 2 contiguous levels of the cervical spine. A total of 330 patients were enrolled, randomized, and received study surgery. All patients were diagnosed with intractable symptomatic cervical DDD at 2 contiguous levels of the cervical spine between C-3 and C-7. Patients were randomized in a 2:1 ratio (TDR patients to ACDF patients). A
total of 225 patients received the Mobi-C TDR device and 105 patients received ACDF. At 24 months only 3.0% of patients were lost to follow-up. On average, patients in both groups showed significant improvements in Neck Disability Index (NDI) score, visual analog scale (VAS) neck pain score, and VAS arm pain score from preoperative baseline to each time point. However, the TDR patients experienced significantly greater improvement than ACDF patients in NDI score at all time points and significantly greater improvement in VAS neck pain score at 6 weeks, and at 3, 6, and 12 months postoperatively. On average, patients in the TDR group also maintained preoperative segmental range of motion at both treated segments immediately postoperatively and throughout the study period of 24 months. Furthermore, at 24 months TDR demonstrated statistical superiority over ACDF based on overall study success rates. The results of this study represent the first available Level I clinical evidence in support of cervical arthroplasty at 2 contiguous levels of the cervical spine using the Mobi-C cervical artificial disc. These results continue to support the use of cervical arthroplasty in general, but specifically demonstrate the advantages of 2-level arthroplasty over 2-level ACDF.

Subsequent to the 2013 publication, Davis and colleagues (2014) reported 48 month outcomes for this same cohort of subjects. The 48 month follow-up rate was 89% for the disc group and 81.2% for the fusion group. Statistical significance for two level disc replacement reported at 24 months was maintained at 48 months for NDI scores, SF-12 PCS scores, patient satisfaction, and overall success. The authors reported the overall success at 48 months for the disc group was statistically superior compared with the fusion group. The fusion group demonstrated a higher rate of adjacent segment degeneration, while the disc group maintained segmental range of motion with no device failure.

Hybrid Surgery
Artificial disc replacement at one level combined with spinal fusion surgery at another level (adjacent or non-adjacent) is referred to as hybrid surgery. There are few clinical trials to support improved health outcomes and patient selection criteria has not been firmly established. Shi and colleagues (2015) performed a retrospective review of 36 patients with adjacent three-level cervical spondylosis who were treated with anterior cervical discectomy and fusion (ACDF) combined with cervical disc arthroplasty (CDA) (hybrid surgery) between October 2008 and October 2012. Clinical evaluation was based on the Neck Disability Index (NDI), Japanese Orthopaedic Association (JOA) score, and postoperative JOA score improvement rate (IR). Radiographic parameters, angular range of motion (ROM) for C2-C7, and ROM for the superior and inferior adjacent segments were measured before the operation, at 1, 3, 6, and 12 months post operation, and at the final follow-up evaluation. All cases were followed for at least 28 months. There was a significant postoperative improvement in NDI and JOA scores compared to preoperative levels. The JOA score improvement rate was 70.83 % at the final follow-up evaluation. One patient required a second surgery for symptomatic adjacent segment degeneration. The mean C2-C7 ROM, which was 46.39 ± 2.41° before the operation, was recovered after 12 months (46.03 ± 4.64°) and was maintained at the last follow-up evaluation (47.50 ± 4.59°). The ROM of the superior and inferior adjacent segments, which was 14.25 ± 1.81° and 10.89 ± 1.65° before the operation, respectively, was recovered after 6 months (14.03 ± 1.46° and 10.75 ± 2.37°, respectively) and increased at the last follow-up evaluation (15.00 ± 1.15° and 11.47 ± 1.84°, respectively). During the follow-up period, heterotopic ossification occurred in three patients. Adjacent segment degeneration was encountered in two cases, and one of these required a second surgical treatment. The authors concluded that the results indicate that hybrid surgery seems to be a promising, acceptable, and alternative surgical approach for the treatment of multi-level cervical disc disease. Some authors have investigated this method of treatment but the evidence in the published peer-reviewed literature is limited by lack of controls, small sample size and short term outcomes. Additional research is needed to clearly establish a role for hybrid technologies.

Lumbar Artificial Disc
Total disc replacement for multisegmental DDD in the lumbar spine is currently considered an off-label indication for disc replacement. Studies comparing the clinical outcomes of single-level disc replacement with disc replacement performed at more than one level remain limited.

There are three 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), the ProDisc®-L Lumbar (SYNTHES Spine, Inc., West Chester, PA), and activL® Artificial Disc (Aesculap Implant Systems, LLC). Charité: The Charité lumbar prosthesis was initially developed in 1984 and has been modified several times, with the latest modification called the SB Charité III. The device consists of two cobalt chromium alloy endplates and a polyethylene sliding core.

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 ± 10 and axial rotation of ± 3.

activL® Artificial Disc is an implant that replaces the function of a damaged or diseased spinal disc. The activL® consists of two metal (cobalt-chromium with a titanium coating) endplates surrounding a plastic (polyethylene) insert. The endplates attach to the patient’s vertebrae, and the plastic insert fits between them. The insert is designed to move during daily activities. The device replaces a disc in the lumbar spine and is intended to relieve pain and allow forward and backward motion at the spinal level.

Prospective randomized controlled FDA trials comparing total disc replacement to lumbar fusion support safety and efficacy with two to five years follow-up for single level disc disease. The results of these trials support these devices are noninferior to lumbar fusion. Several 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. Recent meta-analyses evaluating total lumbar disc replacement versus lumbar fusion continue to support comparable safety and efficacy at two-year follow-up (Wei, et al, 2013; Rao and Cao, 2013). 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 currently available devices result in different clinical outcomes. Data supporting long-term safety, efficacy and improvement of net health outcomes are still being obtained.

Two studies comparing total disc replacement with lumbar fusion concluded that more high quality randomized controlled trials with long-term follow-up are needed to evaluate the effectiveness and safety of lumbar total disc replacement. A meta-analysis by Yajun et al. (2010) of 837 patients from 5 studies found that total disc replacement does not show significant superiority for the treatment of lumbar degenerative disc disease when compared with fusion. A systematic review by van den Eerenbeemt et al. (2010) of 3 randomized controlled trials and 16 prospective studies found no statistically significant differences in mean pain and physical function scores between lumbar fusion and artificial disc replacement with either the Charite or Prodisc artificial discs. Therefore, the existing evidence regarding long-term effectiveness and/or safety is considered insufficient to justify the use of total disc replacement for single level degenerative disc.

Berg et al. (2009) conducted a randomized controlled trial (RCT) comparing total disc replacement (TDR) and instrumented lumbar fusion in 152 patients. Patients in the TDR group were randomized to receive the Charite, Prodisc or the Maverick artificial disc. Outcomes were measured utilizing global assessment (GA), visual analog scale (VAS) for back and leg pain, Oswestry Disability Index, SF36 and EQ5D at 1 and 2 years. There were no differences in outcomes between 1 or 2-level surgery, or between different TDR devices, nor the two different fusion techniques (PLF and PLIF). At 1 year post procedure, the TDR group showed greater improvement in all outcome measurements however by 2 years post procedure, the fusion group had results similar to the TDR group. This study showed that TDR had better outcomes initially however by 2 years, TDR and fusion had similar results. The study is limited by short-term follow-up and subjective outcomes. Additional studies are needed to establish long-term efficacy.

**Charite**

Guyer et al. (2016) conducted a prospective, randomized, controlled, multicenter study to compare outcomes of two lumbar total disc replacements (TDRs) at a 5-year follow-up. In this study, 204 patients received Kineflex-L and 190 patients received CHARITE. Outcomes were measured with Oswestry Disability Index (ODI), visual analog pain scales (VAS), patient satisfaction, neurological status, complications, reoperations, and a composite success score. Radiographic assessment included range of motion, subsidence, and heterotrophic ossification. Both groups showed improvement by 6 weeks in the ODI and VAS scores and remained improved at the 5-year follow-up. ODI scores in both groups were approximately 60 preoperatively vs. 20 at 2- and 5-year follow-up; VAS scores improved >50% by 6 weeks and remained significantly improved. Approximately 11% of both groups underwent reoperation. Segmental range of motion decreased at 3 month, and then increased through 24 months, per radiographic analysis. The authors concluded that there were no significant differences in outcomes during the 5-year follow-up. Both provided improvements by 6 weeks that were maintained. Additional research is needed to validate these findings and compare disc replacement with standard treatment such as fusion.

A randomized controlled trial by Guyer et al. (2009), studied 133 patients (90 CHARITE; 43 fusion) to compare the safety and effectiveness at the five-year follow-up time point of lumbar total disc replacement using the CHARITE artificial disc with that of anterior lumbar interbody fusion (ALIF) with BAK cages and iliac crest autograft. Outcomes were measured using visual analog scale (VAS); validated Oswestry disability index (ODI version 1.0); Short-Form 36 Questionnaire, patient satisfaction, radiographic range of motion, disc height, and segmental translation work status. Mean changes from baseline for ODI, VAS pain scores, and SF-36 questionnaires were similar across groups. Patient satisfaction surveys showed that 78% of CHARITE patients and 72% of fusion patients were satisfied. 65.6% of patients in the CHARITE group and 46.5% patients in the fusion group were employed full-time. Radiographic findings at the five-year follow-up showed the mean range of motion at the index level was 6.0 degrees for CHARITE patients.
and 1.0 degrees for fusion patients. Changes in disc height were also similar for both CHARITE and fusion patients. The authors concluded that the results of this five-year study were consistent with the two-year reports of non-inferiority of CHARITE artificial disc vs. ALIF with BAK and iliac crest autograft and there were no statistical differences found in clinical outcomes between groups. The study is limited by subjective outcomes.

In a multicentric, prospective, randomized study by Geisler et al. (2004), 304 patients with degenerative disc disease were enrolled to compare neurological complications of lumbar artificial disc replacement to lumbar fusion. Patients were randomized into 2 groups: 205 patients underwent treatment with the Charite artificial disc and 99 patients underwent spinal fusion. The two groups had equivalent neurological status postoperatively at 6, 12, and 24 months. The patients who had fusions had a greater incidence of both major and minor complications postoperatively at 0 to 42 days. In the two year follow-up, treatment was classified as a success for more disc replacement patients than fusion patients. The authors conclude that the Charite artificial disc appears safe and effective in treating lumbar degenerative disc disease; however no long term studies on the durability of the Charite artificial disc have been completed.

Blumenthal et al. and McAfee et al. reported new data in 2005 on what appears to be the same group of patients reported on earlier by Geisler et al. In a prospective, multicenter study, 304 patients were randomized 2:1 to treatment with the Charite artificial disc or an instrumented anterior lumbar interbody fusion, with the fusion acting as a control group. Patients were followed for 24 months. Outcomes were measured with the Oswestry Disability Index questionnaire, a Visual Analog Scale, and the SF-36 Health Survey. Both groups improved following surgery, although patients who received the artificial disc recovered more quickly than the control group. Patients in the artificial disc group had lower levels of disability than the control group at every time interval post surgery, had a shorter hospitalization, and had a lower rate of reoperations (5.4% vs. 9.1%) (Blumenthal, 2005). At 24 months post surgery, the artificial disc recipients had a satisfaction rate of 73.7% and an increase in employment of 9.1%. The control group had a satisfaction rate of 53.1% and an increase in employment of 7.2%. Although the satisfaction rate improved, this is a subjective response. Flexion/extension range of motion in the artificial disc group increased by 13.6%, but in the control group decreased by 82.5% at 24 months post surgery as compared to the baseline (McAfee, 2005). The artificial disc group had better restoration of disc height than the control group and there was less subsidence in the artificial disc group than the control group. This study is limited by lack of outcome data beyond 24 months.

In a prospective, randomized, multicenter, FDA-regulated Investigational Device Exemption clinical trial, McAfee et al. (2006), studied 589 patients (71 nonrandomized, 205 randomized and 313 continued access) who underwent total disc replacement with the Charite artificial disc. The study also had a control group of 99 randomized patients who received anterior lumbar interbody fusion (ALIF) with threaded fusion cages and autograft. Patients requiring reoperation included 52 from the Charite group and 10 from the control group as well as an additional 2 patients requiring surgery for adjacent level disease. There were 24 TDR patients who underwent a repeated anterior retroperitoneal approach, with 22 (91.7%) having had a successful removal of the prosthesis. Seven of the 24 TDR prostheses requiring removal were revised to another Charite Artificial Disc. A total of 29 patients (4.9%) in the TDR group required posterior instrumentation and fusion as did 10 (10.1%) in the control group. At 2 years or more of follow-up, 93.9% (553/589) of patients receiving TDR with the Charite Artificial Disc had a successfully functioning prosthesis with a mean of over 7 degrees of flexion-extension mobility. The authors concluded that lumbar total disc replacement did not preclude additional surgery at the primary site with replacements being reversible to a new motion preserving prosthesis, ALIF and/or posterior instrumentation.

Katsimias et al. (2010) prospectively followed 64 patients implanted with the Charite disc. Patients were followed for an average of 55 months (range 24 – 84 months). Outcomes were measured by the Oswestry Disability Index (ODI), visual analog scale (VAS), Short Form-36 (SF-36) health survey and pre and postoperative x-ray studies. Of the 64 patients followed, 57 completed follow-up. All outcome measures showed postoperative improvement at 3 months which persisted throughout the follow-up period. Complications were seen in 3 patients. Radiographic measurement showed that motion was maintained with a mean sagittal rotation during flexion and extension of 6.5° (range 0.5° to 22.4°). The authors conclude that long-term preservation and maintenance of motion is maintained with the Charite artificial disc. Study is limited by lack of a control group, small sample size and no standardized method for radiographic follow-up.

Putzier et al. (2006) reported on 53 patients implanted with the Charite disc at 1 or 2 levels with an average follow-up of 17 years. Segmental fusion or instrumented spondylodesis was required in 23% as a result of pain, implant failure or fracture, or implant subsidence or dislocation. The artificial disc fractured in 13% of the patients. Spontaneous ankylosis occurred in 60% of the patients. The authors concluded that the available long-term results of TDR implantation for the treatment of DDD have not proven this procedure to be as good as or better than fusion.

In the first long-term follow-up study by Lemaire et al. (2005), the results of clinical and radiological outcomes of the Charite artificial disc were reported. Of the initial 107 patients receiving the Charte artificial disc, 100 were followed
for a minimum of 10 years. The prosthesis implanted included 54 one-level, 45 two-level, and 1 three-level procedures were performed for a total of 147 prosthetic implants. Of the 95 patients eligible to return to work, 88 (91.5%) returned to work including 12 patients who worked in heavy labor. Mean flexion/extension motion was 10.3 degrees for all levels. Mean lateral motion was 5.4 degrees. Two patients experienced slight subsidence, although they did not require further surgery. No subluxation of the prostheses and no cases of spontaneous arthrodesis were identified. It appears that clinical outcomes and return to work rates compare to those of fusion for treatment of lumbar degenerative disc disease. This study is limited by small sample size and lack of a comparison group.

David (2007) conducted a retrospective chart and radiographic review of 106 patients who received an arthroplasty with the ChariteSB III prosthesis from 1989-1995. A modified Stauffer-Coventry scale was used to determine clinical outcomes. 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. Mean follow-up time was 13.2 years. Mean ROM in flexion-extension was 10.1 degrees, lateral bending was 4.4 degrees, and 90.6% of implanted prostheses were still mobile. Of the 106 patients, 11 experienced postoperative facet arthrosis, subsidence, adjacent-level disease, and core subluxation. Of the 96 patients working prior to surgery, 86 returned to work. David concluded that clinical outcomes and the rate of return to work was excellent overall. The rate of adjacent-level disease requiring surgical intervention was considerably lower than lumbar fusion therefore demonstrating long-term safety and efficacy of the Charite artificial disc. The study is limited by retrospective study design. Additional studies, preferably long-term randomized controlled trials, are needed to further validate these results.

Kurtz et al. (2007) completed a study of 21 Charite implants from 18 patients undergoing total disc replacement surgery to evaluate the rate of polyethylene wear and surface damage to the implanted discs. The components had been implanted between 1.8 and 16.0 years. These implants were being removed due to pain caused from subsidence, device migration, core dislocation, and osteolysis. The devices showed evidence of adhesive/abrasive wear at both the dome and rim. Additional rim damage included cracking, fracture, and plastic deformation. Radiographic wire marker fracture was observed in 9 of the 21 implants and was always associated with deformation, cracking or fracture of the polyethylene rim. The authors concluded that additional research is warranted to understand the role of polyethylene wear and patients undergoing total disc replacement as they will require regular long-term follow-up.

Lu et al. (2015) conducted a prospective nonrandomized clinical trial aimed to assess the safety and effectiveness of lumbar total disc replacement (TDR) with the Charite III artificial intervertebral disc. Between March 1999 and March 2002, a total of 35 patients with one- or two-level symptomatic degenerative disc disease underwent Charite III lumbar TDR and had an 11 year follow-up. Both clinical and radiological outcomes were assessed. There was an improvement in both lumbar visual analog scale (VAS) and Oswestry Disability Index (ODI) values at the final follow-up. Preoperative VAS was 8.50 ± 0.18, which decreased to 1.46 ± 0.32 at the final follow-up. Preoperative ODI was 41.36 ± 1.87, which decreased to 13.21 ± 2.38 at the final follow-up. Twenty-eight patients (87.5%) had a successful outcome. The range of motion (ROM) of the index level showed a significant decrease compared to a mean angle of 7.4 preoperatively. The ROM of adjacent levels also showed statistically significant decreases. The upper adjacent level ROM decreased from 6.7 preoperatively to 5.2 at the final follow-up. The lower adjacent level ROM decreased from 4.5 preoperatively to 2.4 at the final follow-up. No device failure or major complications were noted. At the final follow-up, prosthetic subsidence was noted in 3 patients. Heterotopic ossification was detected in 25 segments (71.4%). A return to work rate of 75.9% was achieved. The authors concluded that TDR with the Charite III artificial disc is a viable alternative to arthrodesis for the treatment of lumbar degenerative disc disease at one or two levels. This is an uncontrolled study with a small sample size.

**Pro-Disc**

Park et al. (2015) conducted a retrospective analysis to evaluate successful outcomes following lumbar total disc replacement (TDR) using ProDisc II on 54 patients (81 segments) between March 2002 and February 2007. Data was reviewed at 1, 2, 5 and 7 year follow-up. Clinical outcomes were evaluated using Visual Analog Scale (VAS), Oswestry Disability Index (ODI), and subjective satisfaction (4-point scale). Radiographic results included segmental range of motion (ROM). Total VAS scores decreased significantly at postoperative 1 year and 2 year, compared with preoperative VAS score. Although total VAS scores increased until the last follow-up, they remained significantly lower than the preoperative value. All postoperative ODI scores at any follow-up time were significantly lower than the baseline value. There was significant increase in ODI scores between 2-year and last follow-up. The final range of motion (ROM) was shown to be lower than the preoperative ROM and lumbar lordosis was increased and well-maintained during all postoperative follow-up times. Five patients (9.3%) required revision fusion surgeries. A small sample size makes it difficult to decide whether these conclusions can be generalized to a larger population.

In 2011 Delamarter et al. published the results of a prospective randomized multicenter FDA IDE trial evaluating the ProDisc-L compared to circumferential fusion for two-level DDD. Reported outcomes included patient self-assessments, physical, neurological and radiograph assessment pre-operatively and six weeks, three, six, twelve, eighteen and twenty-four months postoperatively. Although ODI scores significantly improved in both groups from preoperative to
postoperative, results were significantly better in the total disc group). A significant reduction in narcotic usage was also reported for the disc group. In the authors opinion two-level lumbar disc replacement using the ProDisc-L device was a viable alternative to lumbar arthrodesis for the treatment of two-level disc disease.

In a prospective, randomized, multicenter, Food and Drug Administration-regulated Investigational Device Exemption clinical trial by Zigler et al. (2007), 286 patients were enrolled to study the ProDisc-L total disc replacement system versus circumferential fusion for the treatment of 1-level degenerative disc disease. Patients were evaluated before and after surgery, at 6 weeks, 3, 6, 12, 18, and 24 months. There were no complications reported for the ProDisc-L. Follow-up at 6 weeks and 3 months showed the ProDisc-L patients recorded SF-36 Health Survey scores significantly higher than the control group (P = 0.018, P = 0.0036, respectively). Comparison of the 2 groups using the Oswestry Low Back Pain Disability Questionnaire (Oswestry Disability Index [ODI]) showed improvement in 91.8% of the investigational and 84.5% of the control patients at 24 months. Review of radiographic range of motion showed maintenance within normal functional range to be 93.7% in the investigational patients and averaged 7.7 degrees. It was concluded that in properly chosen patients, ProDisc-L appears to be superior to circumferential fusion by multiple clinical criteria. The study is limited by short-term follow-up and subjective outcomes. Additional studies are needed to establish long-term efficacy.

Zigler (2004) reported on results of the ProDisc artificial disc with at least six months follow-up. 55 patients were randomized to receive the ProDisc II implant and 23 patients were randomized for a lumbar spinal fusion. The ProDisc II patients had shorter hospital stays, tended to have higher satisfaction rates, experienced more improvement in flexion and lateral bend range of motion, and faster improvement in ambulation and recreational activity than the fusion patients. Both groups had reduced scores in the Oswestry Low Back Pain Disability Questionnaire and the visual analog scale as compared to preoperative values. Zigler concludes that the ProDisc appears to have good outcomes; however, long term studies are needed to assess the durability of the device.

Kim et al. (2007) completed a prospective controlled study of 32 patients who underwent lumbar total disc replacement using the ProDisc II prosthesis. Patients were monitored for 24 months. Nineteen patients had single level total disc replacements (TDR), while 11 patients had TDR at two levels. Radiographic documentation of each patient’s range of motion (ROM) was obtained prior to and every 6 months following TDR. Differences between these measures were compared and the outcomes were reported using degrees as a control measure. Visual analog and disability indexes improved significantly during the follow up period. ROM improved within the first 6 months at levels L3-4 and L4-5 (mean=4.78°being noted. ROM decreased following TDR at the L5-S1 level, with no significant improvement noted at any time. The level of the TDR was found to be a potential negative factor in the minimal gains that were achieved in ROM. Long-term patient follow-up is needed to determine the clinical outcomes of using this prosthesis in the lumbar spine.

Delamarter et al. (2003) reported on 53 patients with at least six months follow-up. In this sample, 35 patients received the ProDisc II implant and 18 patients had lumbar spinal fusion. Disc replacement patients reported less pain and disability than fusion patients in the early period following surgery, however there was no difference after 6 months. These findings are encouraging; however, additional studies are needed to assess the impact on adjacent vertebra.

Tropiano et al. (2005) reported on 64 patients who had single or multiple-level implantation with a Prodisc total lumbar disc replacement. The follow-up period was 7 to 11 years with a mean of 8.7 years. There were significant improvements in back pain, radiculopathy, disability, and modified Stauffer-Coventry scores. Radiographs did not identify loosening, migration, or mechanical failure in any patient. A patient age of less than 45 years and a history of prior lumbar surgery had small but significant negative effects on outcome. Five patients had approach-related complications. The relatively small number of patients and lack of randomization and a control group are weaknesses of this study.

A retrospective study by Yaszay et al. (2008) of 42 patients enrolled in a prospective randomized FDA ProDisc-L trial, were analyzed to determine factors that could influence motion and patient satisfaction following total disc replacement (TDR) at L4/5 or L5/S1. The patients selected received a TDR at L4/5 or L5-S1. Pre- and postoperative disc height and range of motion (ROM) were measured from standing lateral and flexion-extension radiographs. Anterior and posterior disc heights increased; however, the patients’ ROM had decreased. Threshold factors (i.e., anterior and posterior disc heights) that were analyzed showed patients with <9 mm of anterior disc height had an increased ROM of 2.2°of disc height had a -2.2 decrease in their ROM. These findings were considered significant. While improvements were noted based on patient reported visual analog scale scores and Oswestry Disability Index measures, no significant difference between the groups could be found that would explain the average decrease in ROM from 7.0° to 5.7°patients following the use of TDR will determine if the ROM gains will be maintained.

In 3 case series (n=22, 25, 104 patients) of ProDisc implants, Bertagnoli reported statistically significant improvements in pain and disability at 2 to 4 year follow-up (Bertagnoli, 2005a; Bertagnoli, 2005b; Bertagnoli, 2006).
The relatively small number of patients, lack of control groups and short-term follow-up are weaknesses of these studies.

**activL® Artificial Disc**

Garcia et al. (2015) conducted a prospective, multicenter, randomized, controlled, investigational device exemption (IDE) trial to evaluate the comparative safety and effectiveness of lumbar total disc replacement (TDR) in the treatment of patients with symptomatic degenerative disc disease (DDD) who are unresponsive to nonsurgical therapy. The study consisted of patients presenting with symptomatic single-level lumbar DDD who failed at least 6 months of nonsurgical management. They were randomly assigned to treatment with an investigational TDR device (activL, n = 218) or FDA-approved control TDR devices (ProDisc-L or Charité, n = 106). Patient satisfaction with treatment was over 90% in both groups at 2 years. Back pain severity improved 74% with activL and 68% with controls. Oswestry Disability Index (ODI) improved 67% with activL and 61% with controls and Physical Component Summary score (88% vs. 81%) favored the activL group. The percentage of patients working full-time with no restrictions increased from 33% at pretreatment to 57% at 2 years with activL and from 33% to 49% with control. Return to work was approximately 1 month shorter with activL versus controls. The percentage of patients with disc height increase >3mm was 94% with activL and 87% with controls. Change in range of motion in lateral flexion, extension radiographs was statistically greater with activL compared with controls in segmental rotation and translation but not in lateral rotation on side-bending radiographs. The rate of device-related serious adverse events was lower in patients treated with activL versus controls (12% vs. 19%). Surgical reintervention rates were comparable (activL 2.3%, control 1.9%). The authors concluded that the single-level activL TDR is safe and effective for the treatment of symptomatic lumbar DDD through 2 years. The long-term durability of the activL TDR is unknown and requires further investigation.

**Professional Societies**

**American Pain Society**

Guidelines from the American Pain Society (Chou 2014) found insufficient evidence regarding long-term benefits and harms of disc replacement to support recommendations. Vertebral fusion is the most common surgery for chronic, nonspecific low back pain. Surgical instrumentation (use of pedicle screws or other hardware) increases fusion rates, but it is not known if instrumentation improves clinical outcomes. More research with longer follow-up is needed to determine the appropriate role of artificial disc replacement versus fusion. The authors suggest that vertebral fusion be performed for patients who undergo surgical intervention for chronic low back pain.

**Technology Assessments**

A Cochrane review (Jacobs, et al., 2012) was conducted to determine how total disc replacement compared with other treatments for chronic low back pain. The review included seven randomized trials involving 1474 subjects in total, and involved the use of four discs: Charite, Maverick, Prodisc-L, and Flexicore. Six of the trials compared disc replacement to lumbar fusion and one compared disc replacement to nonsurgical treatment consisting of a rehabilitation protocol with cognitive treatment and physical therapy. Follow-up was 24 months in all studies with the exception of one which was five years. The subjects who had disc replacement surgery had slightly better back pain and function outcome scores compared to those who had fusion surgery; the differences did not appear clinically significant. The studies did not demonstrate any other benefit and did not provide any information regarding long-term risks. As a result, the review concluded the spine surgery community should be cautious with regards to adopting the technology on a large scale, long-term outcomes are lacking. Pain relief outcomes are short-term and studies evaluating adjacent segment degeneration and facet joint degeneration are lacking.

National Institute for Health and Care Excellence (NICE): In 2009 NICE concluded that the current evidence on the safety and efficacy of prosthetic intervertebral disc replacement in the lumbar spine is adequate to support its use in the lumbar spine.

An August 2015 Hayes Medical Technology assessment evaluated 7 randomized controlled trials (RCTs), 1 nonrandomized trial, and 6 uncontrolled studies with long-term (7 to 17 years) results published between 2002 through July 2015. A total of 2882 patients who underwent one or two level disc replacement treatment were included. The findings suggest that 1-level lumbar disc replacement (LDR) is comparable in efficacy and safety to fusion for the treatment of symptomatic degenerative disc disease in selected patients who have failed conservative treatment. Questions remain regarding the long-term safety of lumbar disc replacement and there is insufficient evidence comparing LDR with continued treatment with more conservative nonsurgical treatment options.

**U.S. FOOD AND DRUG ADMINISTRATION (FDA)**

**Lumbar**

The following lumbar disc replacement products (product code MJO) have received FDA approval:
The activL® Artificial Disc (Aesculap Implant Systems, LLC) received FDA Premarket Approval on June 11, 2015. It is indicated for people who have fully formed and fully grown bones (are skeletally mature), have low back pain due to a problem with one lumbar disc (as determined by a doctor), have been diagnosed as having degenerative disc disease (DDD) in only one lumbar disc at either level L4/L5 or L5/S1 (as determined by a doctor), and have gone through at least six months of non-surgical treatment without relief. The device is designed to help stabilize the operated spinal level and allow motion at the level. Additional information is available at: http://www.fda.gov/medicaldevices/productsandmedicalprocedures/deviceapprovalsandclearances/recently-approveddevices/ucm455656.htm. Accessed February 8, 2016.

The Charité® intervertebral disc (DePuy Spine, Inc., Raynham, MA) received FDA Premarket Approval on October 26, 2004. It is approved for use in patients who have single-level degenerative disc disease (L4-S1) of the lumbar spine and who have had no relief from low back pain after at least six months of nonsurgical treatment. Additional information is available at: http://www.accessdata.fda.gov/cdrh_docs/pdf4/p040006a.pdf. Accessed February 8, 2016.

As a condition of FDA approval, the manufacturer of the Charité artificial disc must conduct a post-approval study of a maximum of 366 subjects (201 randomized investigational subjects, 67 training investigational subjects, and 98 control subjects) to be evaluated for a total of 5 years post-implantation (FDA).

The Charité® was initially developed in 1984 and has been modified several times, with one prior modification being called the SB Charité III. The INMOTION Lumbar Artificial Disc System (DePuy Spine, Inc., Raynham, MA) is a more recent modification of the initial Charité design, has been cleared by the FDA, and is currently available for implantation.

The ProDisc-L Total Disc Replacement received FDA Premarket Approval on August 14, 2006 for use in patients who have single-level degenerative disc disease of the lumbar spine (L3-S1) and who have had no relief from low-back pain after at least 6 months of nonsurgical treatment. Additional information is available at: http://www.fda.gov/MedicalDevices/ProductsandMedicalProcedures/DeviceApprovalsandClearances/Recently-ApprovedDevices/ucm077620.htm. Accessed February 8, 2016.

Cervical

The following cervical disc replacement products (product code MJO) have received FDA approval:

• Mobi-C® Cervical Disc Prosthesis received premarket approval on August 7, 2013. (P110002). The Mobi-C® Cervical Disc Prosthesis consists of two metal (cobalt-chrome alloy2) endplates and a plastic (ultra-high molecular weight polyethylene) insert that fits between the endplates. The device is placed between two adjacent neck bones (cervical vertebrae) to replace a diseased cervical disc that is causing arm pain and/or weakness or numbness. The device is indicated for skeletally mature patients (people who have stopped growing) to replace a cervical disc in the neck (from C3-C7) following removal of the disc for conditions that result from a diseased or bulging disc at only one spinal level. The device should help stabilize the operated spinal level. Unlike a fusion procedure, the Mobi-C® Cervical Disc Prosthesis is designed to allow motion at the operated spinal level. The effects of the diseased disc removal should include pain relief and improved function. Additional information is available at: http://www.accessdata.fda.gov/cdrh_docs/pdf11/P110002a.pdf. Accessed February 8, 2016.

• Mobi-C® Cervical Disc Prosthesis (two-level) received premarket approval of August 23, 2013. (P110009). The Mobi-C® Cervical Disc Prosthesis consists of two metals (cobalt-chrome endplates and a plastic (ultra-high molecular weight polyethylene) insert that fits between the endplates. The device is placed between two adjacent neck bones (cervical vertebrae) to replace a diseased cervical disc at two adjacent levels that are causing arm pain and/or weakness or numbness. The device is intended for skeletally mature patients (people who have stopped growing) to replace two adjacent cervical discs in the neck (from C3-C7) following removal of the discs for conditions that result from diseased or bulging discs at two adjacent spinal levels. The two devices should help stabilize the operated spinal levels. Unlike a fusion procedure the Mobi-C® Cervical Disc Prosthesis is designed to allow motion at the operated spinal levels. The effects of removing the diseased discs should include pain relief and improved function. Additional information is available at: http://www.accessdata.fda.gov/cdrh_docs/pdf11/P110009a.pdf. Accessed February 8, 2016.

• ProDisc-C Total Disc Replacement received premarket approval on December 17, 2007 (P070001). The device is indicated for skeletally mature patients for reconstruction of the disc from C3-C7 following single-level discectomy for intractable symptomatic cervical disc disease (SCDD). Symptomatic cervical disc disease is defined as neck or arm (radicular) pain and/or a functional/neurological deficit with at least one of the following conditions confirmed by imaging (CT, MRI, or x-rays): herniated nucleus pulposus, spondylosis (defined by the presence of osteophytes) and/or loss of disc height. The ProDisc-C total disc replacement is implanted via an open anterior approach. Patients receiving the ProDisc-C total disc replacement should have failed at least six weeks of non-operative treatment prior to implantation. Additional information is available at: http://www.accessdata.fda.gov/cdrh_docs/pdf7/p070001a.pdf. Accessed February 8, 2016.

• Prestige LP Cervical Disc received premarket approval on July 24, 2014. Indicated for skeletally mature patients for reconstruction of the disc at one level from C3-C7 following single-level discectomy for intractable radiculopathy (arm pain and/or a neurological deficit) with or without neck pain, or myelopathy due to a single-level abnormality localized to the level of the disc space and at least one of the following conditions confirmed by imaging (CT, MRI, X-rays): herniated nucleus pulposus, spondylosis (defined by the presence of osteophytes) and/or loss of disc height. The Prestige LP Cervical Disc is placed between two adjacent cervical vertebrae to replace a diseased cervical disc that is causing neck or arm (radicular) pain and/or a functional/neurological deficit. Additional information is available at: http://www.accessdata.fda.gov/cdrh_docs/pdf10/P100001a.pdf. Accessed February 8, 2016.

Cervical Disc Prosthesis consists of two metal (cobalt-chrome alloy2) endplates and a plastic (ultra-high molecular weight polyethylene) insert that fits between the endplates. The device is placed between two adjacent neck bones (cervical vertebrae) to replace a diseased cervical disc at two adjacent levels that are causing arm pain and/or weakness or numbness. The device is indicated for skeletally mature patients (people who have stopped growing) to replace a cervical disc in the neck (from C3-C7) following removal of the disc for conditions that result from a diseased or bulging disc at only one spinal level. The device should help stabilize the operated spinal level. Unlike a fusion procedure, the Mobi-C® Cervical Disc Prosthesis is designed to allow motion at the operated spinal level. The effects of the diseased disc removal should include pain relief and improved function. Additional information is available at: http://www.accessdata.fda.gov/cdrh_docs/pdf11/P110002a.pdf. Accessed February 8, 2016.

• Mobi-C® Cervical Disc Prosthesis (two-level) received premarket approval of August 23, 2013. (P110009). The Mobi-C® Cervical Disc Prosthesis consists of two metals (cobalt-chrome endplates and a plastic (ultra-high molecular weight polyethylene) insert that fits between the endplates. The device is placed between two adjacent neck bones (cervical vertebrae) to replace a diseased cervical disc at two adjacent levels that are causing arm pain and/or weakness or numbness. The device is indicated for skeletally mature patients (people who have stopped growing) to replace two adjacent cervical discs in the neck (from C3-C7) following removal of the discs for conditions that result from diseased or bulging discs at two adjacent spinal levels. The two devices should help stabilize the operated spinal levels. Unlike a fusion procedure the Mobi-C® Cervical Disc Prosthesis is designed to allow motion at the operated spinal levels. The effects of removing the diseased discs should include pain relief and improved function. Additional information is available at: http://www.accessdata.fda.gov/cdrh_docs/pdf11/P110009a.pdf. Accessed February 8, 2016.

• ProDisc-C Total Disc Replacement received premarket approval on December 17, 2007 (P070001). The device is indicated for skeletally mature patients for reconstruction of the disc from C3-C7 following single-level discectomy for intractable symptomatic cervical disc disease (SCDD). Symptomatic cervical disc disease is defined as neck or arm (radicular) pain and/or a functional/neurological deficit with at least one of the following conditions confirmed by imaging (CT, MRI, or x-rays): herniated nucleus pulposus, spondylosis (defined by the presence of osteophytes) and/or loss of disc height. The ProDisc-C total disc replacement is implanted via an open anterior approach. Patients receiving the ProDisc-C total disc replacement should have failed at least six weeks of non-operative treatment prior to implantation. Additional information is available at: http://www.accessdata.fda.gov/cdrh_docs/pdf7/p070001a.pdf. Accessed February 8, 2016.

• Prestige LP Cervical Disc received premarket approval on July 24, 2014. Indicated for skeletally mature patients for reconstruction of the disc at one level from C3-C7 following single-level discectomy for intractable radiculopathy (arm pain and/or a neurological deficit) with or without neck pain, or myelopathy due to a single-level abnormality localized to the level of the disc space and at least one of the following conditions confirmed by imaging (CT, MRI, X-rays): herniated nucleus pulposus, spondylosis (defined by the presence of osteophytes) and/or loss of disc height. The Prestige LP Cervical Disc is placed between two adjacent cervical vertebrae to replace a diseased cervical disc that is causing neck or arm (radicular) pain and/or a functional/neurological deficit. Additional information is available at: http://www.accessdata.fda.gov/cdrh_docs/pdf10/P100001a.pdf. Accessed February 8, 2016.
x-ray): herniated nucleus pulposus, spondylosis (defined by the presence of osteophytes), and/or visible loss of disc height as compared to adjacent levels. Additional information is available at: http://www.accessdata.fda.gov/cdrh_docs/pdf9/P090029a.pdf Accessed February 10, 2016.

Prestige® Cervical Disc System received premarket approval on July 16, 2007 (P060018). 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 PRESTIGE® device is implanted via an open anterior approach. Intractable radiculopathy and/or myelopathy should present with at least one of the following items producing symptomatic nerve root and/or spinal cord compression which is documented by patient history (e.g., pain [neck and/or arm pain], functional deficit, and/or neurological deficit), and radiographic studies (e.g., CT, MRI, x-rays, etc.): 1) herniated disc, and/or 2) osteophyte formation. The safety and effectiveness of the device has not been established in patients who have not undergone at least six weeks of conservative treatment or had signs of progression or spinal cord/nerve root compression with continued non-operative care. Additional information is available at: http://www.fda.gov/MedicalDevices/ProductsandMedicalProcedures/DeviceApprovalsandClearances/Recently-ApprovedDevices/ucm408505.htm Accessed March 15, 2016.

- Bryan® Cervical Disc received premarket approval on May 12, 2009 (P060023). 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. Intractable radiculopathy and/or myelopathy is defined as any combination of the following: 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). Patients receiving the Bryan Cervical Disc should have failed at least six weeks of non-operative treatment prior to implantation. Additional information is available at: http://www.fda.gov/MedicalDevices/ProductsandMedicalProcedures/DeviceApprovalsandClearances/Recently-ApprovedDevices/ucm408505.htm Accessed February 8, 2016.

- SECURE®-C Artificial Cervical Disc received premarket approval on September 28, 2012 (P100003) The SECURE®-C Artificial Cervical Disc is intended to be used in skeletally mature patients (people who have stopped growing) to replace a cervical disc in the neck (from C3-C7) following removal of the disc for conditions that result from a diseased or bulging disc (intractable radiculopathy3 or myelopathy4) at only one level. The device should help stabilize the operated disc in the neck. Unlike a fusion procedure5, the SECURE®-C Artificial Cervical Disc is designed to allow motion at the operated disc. The effects of the diseased disc removal should include pain relief and improved function. Additional information is available at: http://www.fda.gov/MedicalDevices/ProductsandMedicalProcedures/DeviceApprovalsandClearances/Recently-ApprovedDevices/ucm322270.htm Accessed February 8, 2016.

- PCM Cervical Disc System received premarket approval on October 26, 2012 (P100012) The PCM Cervical Disc consists of two metal (cobalt-chrome alloy) endplates and a plastic (ultra-high molecular weight polyethylene) insert that fits between the endplates. The device is placed between two adjacent neck bones (vertebrae) to replace a diseased cervical disc2 that is causing arm pain and/or weakness or numbness. The PCM Cervical Disc is intended to be used in skeletally mature patients (people who have stopped growing) to replace a cervical disc from C3-C7 following removal of the disc for conditions that result from a diseased or bulging disc (intractable radiculopathy3 or myelopathy4) at only one level. The device should help stabilize the operated disc in the neck (spinal level). Unlike a fusion procedure5, the PCM Cervical Disc is designed to allow motion at the operated spinal level. The effects of the diseased disc removal should include pain relief and improved function. Additional information is available at: http://www.fda.gov/MedicalDevices/ProductsandMedicalProcedures/DeviceApprovalsandClearances/Recently-ApprovedDevices/ucm327487.htm Accessed February 8, 2016.

**CENTERS FOR MEDICARE AND MEDICAID SERVICES (CMS)**

Medicare does not have a National Coverage Determination (NCD) for cervical artificial disc replacement. Local Coverage Determinations (LCDs) exist, refer to the LCDs for **Category III CPT® Codes**, **Non-Covered Category III CPT Codes**, **Non-Covered Services** and **Services that are Not Reasonable and Necessary**

Medicare does not cover lumbar artificial disc replacement (LADR) for Medicare population over 60 years of age. For Medicare beneficiaries 60 years of age and younger, there is no national coverage determination for LADR, leaving such determinations to continue to be made by the local contractors. Refer to the NCD for **Lumbar Artificial Disc Replacement (LADR) (150.10)**. LCDs exist; see the LCDs for **Non-Covered Services** and **Services that are Not Reasonable and Necessary**. Accessed February 10, 2016.
REFERENCES


POLICY HISTORY/REVISION INFORMATION

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<td>06/01/2016</td>
<td>• Reformatted and reorganized policy; transferred content to new template&lt;br&gt;• Updated coverage rationale; added language to clarify lumbar artificial total disc replacement is not medically necessary for treating single or multiple level degenerative disc disease in skeletally mature patients&lt;br&gt;• Updated supporting information to reflect the most current clinical evidence, FDA and CMS information, and references&lt;br&gt;• Archived previous policy version 2015T0437P</td>
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