TITLE: Artificial Disc Replacement for Degenerative Disc Disease of the Lumbar Spine

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ARTIFICIAL DISC REPLACEMENT FOR DEGENERATIVE DISC DISEASE OF THE LUMBAR SPINE

INTRODUCTION

The California Technology Assessment Forum has been asked to review the scientific literature on the safety and efficacy of artificial spinal disc replacement for the treatment of low back pain caused by lumbar degenerative disc disease.

This review will focus on the Charité Artificial Disc, as it is the only device currently approved by the FDA. At least three other devices (Prodisc, Maverick Artificial Disc, FlexiCore Intervertebral Disc) are currently in clinical trials, but are not considered because of the limited data on clinical outcomes in the peer-reviewed literature.

BACKGROUND

Back Pain

Low back pain is the most common cause of morbidity and chronic pain in the U.S. with an incidence approaching 20% (Deyo and Tsui-Wu, 1987). In most cases, the causes of both acute and chronic back pain are benign. The physiologic basis for low back pain is complex in part because of its complex anatomy. The spine is comprised of bones, joints, ligaments, fatty tissue, multiple layers of muscles and nerves. These structures are supplied by an intricate arterial and venous system and lie in close proximity to the skin with its sensory receptors. Spinal structures and tissues that possess either unmyelinated nerves or substance P or related peptides are assumed to have the capacity to cause pain. Such structures include the posterior facet joints, bones and periosteum, muscles, tendons, fascia, ligaments, nerve roots, dorsal root ganglia, dura mater and the intervertebral disc (Haldeman, 1999).

The specific tissue responsible for back pain is identified in less than 20% of cases (Frymoyer, 1988). In most cases a trial of conservative treatment is appropriate. A more aggressive diagnostic evaluation is usually done in cases of progressive neurologic deficit, bowel or bladder incontinence, a history of cancer or significant trauma (Swenson, 1999).

Up to 40% of chronic low back pain has been reported to be originated from the intervertebral disc (Schwarzer, Aprill et al., 1995), but there is controversy surrounding its diagnosis and management. Low back pain caused by intervertebral disc disease may be insidious or sudden in onset. Pain is usually at the center of the back and may radiate to the buttocks or thighs. It is usually increased by sitting and improved by lying down. Pain usually improves within two weeks, but may require up to 12 weeks for complete resolution.
The usual treatments for low back pain include non-steroidal anti-inflammatory drugs, opioid analgesics and antidepressants. Nonpharmacologic techniques such as physical therapy, acupuncture, massage and relaxation also may be helpful. Epidural corticosteroid injections can provide short relief. For the minority of patients with persistent pain due to degenerative disc disease, treatment with spinal fusion is sometimes recommended.

**Lumbar Spine Fusion Surgery for Degenerative Disc Disease**

Patients with clear discogenic pain may benefit from complete surgical removal of the intervertebral disc and vertebral fusion. Measurable decreases in preoperative pain have been noted in over 80% of patients in various series (Lee, Vessa et al., 1995). One randomized clinical trial reported statistically significant improvements in pain and disability with lumbar fusion compared with conservative management (Fritzell, Hagg et al., 2001). Minimally invasive intradiscal techniques and percutaneous procedures have recently been employed as an alternative to conventional surgical methods. These have included chemonucleolysis, manual percutaneous discectomy, automated percutaneous discectomy, laser-assisted discectomy, endoscopic posterolateral discectomy, laparoscopic discectomy and fusion (Fehlings, 1996; Maroon, Quigley et al., 1996) and intradiscal electrothermal therapy.

Fusion surgery for the treatment of lower back pain has been done since the early 1900’s. Spine fusion procedures were initially performed to limit the deformity created by tuberculosis infections. Serendipitously, it was found that the surgery also reduced the patient’s low back pain. Over time, spine fusion procedures have had variable popularity for the treatment of lumbar degenerative disc disease and are still somewhat controversial. Some spine surgeons do not believe fusion surgery is ever indicated for the treatment of low back pain from lumbar degenerative disc disease. Others are very willing to offer patients a fusion procedure, including multiple-level fusion surgery. Today, spinal fusion surgery is quite common in the U.S. with over 250,000 procedures performed annually (Abraham, Herkowitz et al., 1998).

Spinal fusions can be performed by an anterior or posterior approach. The majority of spinal fusion operations in the U.S. have been by the posterior approach, which in turn is comprised of three main techniques: a posterior lumbar interbody fusion (PLIF), a posterolateral gutter fusion surgery and a transforaminal lumbar interbody fusion (TLIF). In these procedures, the paraspinal muscles must be detached, thus potentially leading to paraspinal muscle weakness and atrophy in some patients. The PLIF and TLIF allow for placement of bone or a cage in the disc space. There are two types of anterior fusion procedures: the anterior/posterior lumbar fusion and the anterior lumbar interbody fusion (ALIF). In both operations, the spinal column is accessed through an incision in the abdomen, with some procedures done with either a mini-laparotomy or via an endoscopic approach. The anterior approach preserves the paraspinal musculature and nerves. In addition, bone graft is placed in front of the spine which therefore receives more compression and may fuse more efficiently (Burkus, Gornet et al., 2002). Risks of ALIF surgery include damage to large blood vessels and in males, retrograde ejaculation in around 1% of cases (Fowler, Dall et al., 1995). Fusing the
spine is designed to decrease back pain by limiting the motion at a painful motion segment. Fusion occurs over three to six months (and up to 18 months) following surgery.

Indications for lumbar fusion surgery for back pain caused by degenerative disc disease:

- Failed extensive conservative treatment (such as physical therapy, medications)
- Continued low back pain that limits activities
- Clear diagnosis of pain from a specific disc space

There are concerns that lumbar fusion may accelerate degeneration at other disc levels. Rigid immobilization of one spinal segment can lead to hypermobility of adjacent segments which is thought to accelerate degenerative changes in the adjacent discs (Etebar and Cahill, 1999; Chou, Hsu et al., 2002; Gertzbein and Hollopeter, 2002). Artificial discs have been developed to allow removal of the diseased disc while preserving normal range of motion at the disc.

**Charité Artificial Disc**

The Charité Artificial Disc was developed to treat severe, chronic low back pain by replacing the damaged or worn out spinal disc in the lower back with an artificial disc. The device is made by DePuy Spine, a division of Johnson and Johnson, Inc. It is made of two metallic endplates and a sliding plastic core designed to help align the spine and maintain the spine’s natural flexibility. The Charité Artificial Disc was designed to restore disc space height, to restore motion segment flexibility, to prevent disc degeneration at adjacent segments, to reduce or eliminate pain from motion or from nerve compression and to improve the patient's functional activities. It was designed to be durable with a life span of 40 years.

The artificial disc is an alternative to the current surgical treatment for treating chronic low back pain from degenerative disc disease - lumbar spinal fusion surgery. In spine fusion, the surgery is designed to stop motion at the painful level of the spine. In the past, implants have been used to help provide initial fixation, such as metal screws and rods and/or cages that are inserted between the vertebrae. Because the fusion eliminates the motion in the lumbar spinal segment, the pain caused by the motion is reduced or eliminated. When done correctly for the right indications, a fusion has a high success rate in reducing or eliminating the patient's pain (Lee, Vessa et al., 1995; Fritzell, Hagg et al., 2001). However, because fusion by design limits range of motion, it may transfer extra stress to discs above and below the fusion site. Because the artificial disc allows continued motion in the spinal segment, it is theorized that this may be a preferable alternative to spinal fusion surgery.

The surgical approach is typically through an anterior retroperitoneal route. Meticulous attention to implantation is required to ensure that the articulating surfaces of the endplates are parallel in order to restore normal biomechanics. Patient positioning is important so that radiographic confirmation of the implant position can be seen easily by the
surgical team. A spine surgeon (either an orthopedic spine surgeon or a neurosurgeon) uses specially designed instruments to remove the damaged disc, create a space between two vertebrae for the implantation of the artificial disc and fit the Charité disc in between the two vertebrae. The disc replacement procedure is performed with the patient under general anesthesia and typically takes one to two hours to complete. During the U.S. clinical trials, the average hospital stay for patients was about four days. Surgeons generally advise restriction of certain activities for a certain time period following the surgery and some surgeons may prescribe a back brace.

**Indications for Artificial Disc Replacement**

- Lumbar degenerative disc disease confirmed by the patient's medical history and an x-ray, MRI and/or other diagnostic tests
- Symptoms not relieved with at least six months of non-surgical treatment (pain medications, physical therapy, manipulation, ice and/or heat therapy, etc.)
- The damaged disc is located at either L4-L5 or L5-S1
- No or minimal (less than 3 mm) spondylolisthesis

**Contraindications for Artificial Disc Replacement**

- Multi-level disc degeneration
- Instability in the spine (such as spondylolisthesis, fracture or spinal tumor)
- Osteoporosis or osteopenia
- Prior spine surgery
- Pregnancy
- Facet joint arthritis

**The Charité Artificial Disc Replacement Surgery**

**Technology Assessment (TA)**

**TA Criterion 1: The technology must have final approval from the appropriate regulatory bodies.**

On October 26, 2004 the U.S. Food and Drug Administration (FDA) approved the Charité™ artificial disc for use in patients who have severe lower back pain caused by degenerative disc disease and have obtained little or no pain relief after at least six months of non-surgical treatments, such as pain medications, physical therapy, injections and/or manipulation. The FDA clearance for disc replacement is a single level of the lower spine, either L4-L5 or L5-S1.

**TA criterion 1 is met.**
TA Criterion 2: The scientific evidence must permit conclusions concerning the effectiveness of the technology regarding health outcomes.

The Medline database, Cochrane clinical trials database, Cochrane reviews database and the Database of Abstracts of Reviews of Effects (DARE) were searched using the key words artificial disc or Charité. These were cross-referenced with the keywords lumbar and human. The search was performed for the period from 1966 through December 2004. The bibliographies of systematic reviews and key articles were manually searched for additional references. The abstracts of citations were reviewed for relevance and all potentially relevant articles were reviewed in full.

The search identified four uncontrolled case-series (Cinotti, David et al., 1996; Lemaire, Skalli et al., 1997; Zeegers, Bohnen et al., 1999; Scott and Harrison, 2000) describing the outcomes for a total of 215 patients. All of the centers were in Europe.

One U.S. study (Geisler, Blumenthal et al., 2004) that randomized 305 patients was identified. Two year follow-up outcome data were available for 267 (88%) of the participants according to data from the FDA website. Reporting of the study design in the primary publication of the study was poor. No mention was made about the method of randomization, allocation concealment or blinding of outcome assessment. The authors did not describe recruitment for the study, the number lost to follow-up, the reasons for loss to follow-up and adverse outcomes other than neurologic sequelae. Furthermore, there is no description of the statistic methods used. A report of 60 patients from one center (McAfee, Fedder et al., 2003) in the study gives more detail on the recruitment and randomization, but it is not clear if the same methods were used at all sites and in the final analysis.

TA criterion 2 is met.

Level of evidence: 1 and 5.

TA Criterion 3: The technology must improve the net health outcomes.

The benefits of treatment for low back pain include pain relief, decreased disability/restoration of function, cessation of narcotic therapy and return to work. The primary outcome measure used in most studies of back pain is change in pain score as measured by a 10-point visual analog scale (VAS). Changes of 2 points or greater are generally considered clinically significant. Disability is usually measured by the 100-point Oswestry low back pain Disability Index (ODI).
Case Series

Four case-series have been published documenting the European experience with this disc since 1987. One publication (Blumenthal, Ohnmeiss et al., 2003) presents data from the treatment arm of the U.S. randomized controlled trial (RCT) discussed below as a prospective case series. As these data are better understood in comparison to the control arm results, they will be discussed in the context of the RCT below.

Cinotti et al. (1996) reported on 46 Italian patients who were evaluated clinically and radiographically at least 2 years after artificial disc surgery. There were 21 men and 25 women with an average age of 36 years (range 27-44 years). Preoperative diagnosis included disc degeneration in 22 patients and failed disc excision in 24 patients. All patients had computed tomography (CT) or magnetic resonance imaging (MRI) evidence of disc degeneration and pain on provocative discography. The disc prosthesis was implanted at a single vertebral level in 36 patients and at two levels in 10 patients. Follow-up evaluation was performed after an average of 3.2 years (range, 2-5 years). 63% of patients reported satisfactory results, which the authors note is lower than the reported satisfaction in studies of fusion surgery (65%-93%). The success rate was higher in patients who underwent disc replacement at a single level (69% vs. 40%, p=0.004) and in those with no previous back surgeries (77% vs. 50%, p=0.04). Eight patients who had unsatisfactory results underwent posterolateral fusion. Two patients underwent removal of the prosthesis. No failure of the implants, loosening or wear of the polyethylene core were found. Other surgical complications were not reported. Vertebral motion averaged 9º at the operated levels and 16º at the adjacent levels. No data on pain scores or the ODI were presented. The authors suggest that the data indicate that the device should only be used at a single level. They also recommend longer-term, randomized, prospective studies to establish whether disc prosthesis may offer advantages compared with spinal fusion. They specifically note the experience of hip replacement with the importance of assessment of prosthesis failure, material wear and implant loosening at 10-year follow-up.

The largest case series (Lemaire, Skalli et al., 1997) reported outcomes on 105 French patients with an average of 51 months follow-up. The average age was 39 years (range 24-50) and 35% were female. The artificial disc was implanted at one level in 58 patients, two levels in 46 patients and three levels in one patient. In this series, 79% of the patients had an excellent result and 87% returned to work. A radiologically, good outcome was correlated with restoration of a well-balanced lordosis and with segmental mobility. Factors leading to failure were posterior facet arthritis, osteoporosis, structural deformities and secondary facet pain. Eleven (10%) complications were noted including one end plate fracture requiring fusion, one case of an endplate migration into osteoporotic bone, five vascular complications and two neurologic complications.

It is not clear why patient satisfaction is higher in this series compared with that of Cinotti et al. (1996). This series had a higher proportion of patients undergoing multi-level device implantation, which Cinotti suggested should result
in worse results. The most likely explanation is that different indications for device implantation were used in the two studies, but differences cannot be identified from the study methods. The criteria for “success” may also be different. This highlights the pitfalls inherent in any comparison across case-series. Randomized comparisons between groups with the same indications for surgery using standardized outcome measures are essential for unbiased assessment of the benefits of the device.

Zeegers et al. (1999) reported on 50 (out of 350) Dutch patients who received an artificial disc with two years follow-up. The mean age of the patients was 43 years (24-59 years) and 60% were female. The artificial disc was implanted at one level in 29 patients, two levels in 18 patients and three levels in three patients. They reported a satisfactory clinical result in 70% of cases. As in Cinotti et al. (1996), subgroup analysis revealed that patients with an isolated discopathy, without previous spinal operations or other pathology at the same or other spinal level, benefited more from the surgery (81% vs. 66%, p not reported). However, there was no difference in outcome between patients receiving disc replacement at a single level compared with multiple levels. A 13% rate of permanent side effects and/or complications was observed. 4% were related to poor implantation technique. There were no problems related to the material of the prosthesis. Twenty-four re-operations were performed in 12 patients. These included three vascular surgeries for repair of the aorta, two hematoma evacuations and multiple spinal orthopedic procedures. Permanent complications occurred in 16% of patients at two year follow-up including leg dysesthesias (6%), sympathetic nerve damage (8%) and prosthesis malpositioning (2%).

Finally, Sott and Harrison et al. (2000) reported a small case series of 14 British patients with a mean follow-up of 48 months (range 18-68 months). The main indication for surgery was degenerative lumbar disc disease with segmental instability. The mean age of the patients was 48 years (range 31-61 years) and 43% were female. A good outcome was observed in 10 patients (71%). The authors reported no major complications, but note that 36% of patients reported a warm left foot due to left paravertebral sympathetic nerve damage. One patient required fusion for continued symptoms and another experienced endplate migration even though she was not osteoporotic.

These four case-series report outcomes that are similar to those reported for lumbar spinal fusion, but some series report long-term complications and the length of follow-up is not sufficient to assess the possibility of prosthesis failure. The different definitions of success and lack of standard outcomes such as the VAS and ODI scores make it difficult to assess the benefits of the device. Randomized trials with long-term follow-up are needed to assess whether the theoretical benefits of preserved joint mobility with the Charité Artificial Disc outweigh possible procedure and device-related complications.

**Randomized Clinical Trials**

One randomized trial of the Charité Artificial Disc has been published (Geisler, Blumenthal et al., 2004) and portions of the study have been reported in multiple publications (Blumenthal, Ohnmeiss et al., 2003; McAfee, Fedder et al.,
The study recruited 375 patients at 14 spine centers in the U.S. The initial five patients treated with an artificial disc at most centers (71 patients) were considered training cases and were not included in the randomized comparisons. Randomization was done with a two to one ratio. Two hundred and five patients received the Charité lumbar artificial disc and 99 patients received the control surgery (ALIF with BAK threaded fusion cages and bone graft).

Inclusion criteria were age 18-60, single-level L4-5 or L5-S1 symptomatic degenerative disc disease confirmed by discography, ODI score greater than 30, VAS score greater than 4/10, failed more than six months of nonoperative care, back and/or leg pain without nerve compression, less than three prior abdominal surgeries and compliance with the follow-up schedule. Exclusion criteria included previous fusion, multilevel degeneration, prior fracture in the lower lumbar spine, non-contained disc herniation, osteoporosis or metabolic bone disease, spondylolisthesis greater than 3 mm, positive straight leg raise, scoliosis greater than 11 mm, spinal tumor, infection, facet joint arthrosis, psychological disorder and morbid obesity. Additional exclusions were metal allergy, the presence of a bone growth stimulator elsewhere in the spine, participation in another study, arachnoiditis, pregnancy, chronic steroid use or presence of an autoimmune disease.

The age and sex distribution of the patients was not reported although the authors note that the two treatment groups did not differ significantly by age or sex. The majority of the patients were treated at the L5-S1 level (69%). No other descriptive data were provided.

No descriptions of allocation concealment or attempts at patient blinding were presented in the paper analyzing the main results. The primary outcome measure is not specified, nor are the statistical methods used to analyze the data. The number of patients available for analysis at each time point was not reported nor was there any description of patients lost to follow-up.

For both patient groups, the VAS and ODI scores improved significantly after surgery. The mean ODI score decreased from 51 to 26 (-25) in the Charité group and from 52 to 30 (-22) in the control group. The change in scores did not differ between groups (p=0.54). However, the percentage of patients experiencing at least a 25% reduction in ODI was greater in the Charité group (62% vs. 49%, p=0.04). Similarly, the VAS score decreased from 7.2 to 3.1 (-4.1) in the Charité group and from 7.2 to 3.6 (-3.6) in the control group. The change in scores did not differ between groups (p=NS). However, the percentage of patients experiencing at least a 2.0 reduction in VAS was greater in the Charité group (65% vs. 56%, p=0.10), though not statistically significant.

These findings in favor of the Charité device may be biased due to the lack of blinding. The primary outcome measures were subjective, based on patient self-report of pain and disability. Prior to randomization, the participants may have believed that the new device was better. They were participating in a trial of a new technology with a two-to-one randomization design in favor of the new device. This suggests that the higher likelihood of receiving the new
device was used to enhance recruitment into the study. Those randomized to the artificial disc were likely to be delighted, while those randomized to standard therapy were likely to be disappointed.

Radiographic findings showed an average range of motion of 7.4° for patients in the Charité group compared with 1.1° in the fusion group. No data were presented about whether this difference correlated with a reduction in degenerative disease in adjacent discs.

While perioperative and long-term complications were not reported, adverse neurologic events were similar in both groups (16.6% vs. 17.2%, p NS). Major neurologic events (nerve root injury, motor deficits, neuropathic pain) were also similar in both groups (4.9% vs. 4.0%).

The data available from the FDA website indicate that follow-up was similar in the two groups. The “intention to treat” analysis at 24 months included 182- out of 205 patients randomized to the Charité group and 85 out of 99 patients randomized to the control group. The results presented there are similar to the published data, but the numbers differ slightly. For instance, the percentage of patients experiencing at least a 25% reduction in ODI was reported to be 70% in the Charité group and 58% in the control group (p=0.54). These numbers are all slightly higher than those reported in the peer-reviewed article. The FDA data also report a 4% device failure rate in the Charité group compared with a 1% failure rate in the control group. Those data have not yet been published.

Harms
Harms related to placement of the artificial disc have been poorly described in the published literature. In addition to usual perioperative complications like myocardial infarction and venous thromboembolic disease, important complications with the anterior approach to the spine include vascular injury and damage to the paraspinous sympathetic chain. These risks may be increased with this procedure due to the instrumentation needed to restore disc space height and the need to precisely position the artificial disc.

A Dutch group (van Ooij, Oner et al., 2003) described the possible short and long-term, unsatisfactory results of disc prosthesis surgery. They note that most patients receiving artificial discs are between the ages of 30 and 50 years. In these active patients, complications can be expected to increase with longer follow-up, similar to total joint replacements in the extremities. They report a series of 27 patients who presented to a tertiary university referral center with unsatisfactory results or complications after Charité disc replacement. The group consisted of 15 women and 12 men. Their mean age was 40 years (range 30-67 years), at the time of operation. The mean time from disc replacement surgery was 53 months (range 11-127 months). In two patients, an early removal of the prosthesis was required and in two patients, a late removal was required. In 11 patients, a second spinal reconstructive salvage procedure was performed. Mean follow-up for 26 patients with mid and long-term evaluation was 91 months (range 15-157 months). Early complications were the following: in one patient, an anterior luxation of the prosthesis after
one week necessitated removal and cage insertion, which failed to unite. In another patient with protheses at L4-L5 and L5-S1, the prosthesis at L5-S1 dislocated anteriorly after three months and was removed after 12 months. Abdominal wall hematoma occurred in four cases. Retrograde ejaculation with loss of libido was seen in one case and erection weakness in another case. A temporary benefit was experienced by 12 patients, while 14 patients reported no benefit at all. Main causes of persistent complaints were degeneration at another level in 14, subsidence of the prosthesis in 16 and facet joint arthrosis in 11. A combination of pathologies was often present. Slow anterior migration was present in two cases, with compression on the iliac vessels in one case. Polyethylene wear was obvious in one patient, 12 years after operation. In eight cases, posterior fusion with pedicle screws was required. In two cases, the prosthesis was removed and the segment was circumferentially fused. These procedures resulted in suboptimal, long-term results. In this relatively small group of patients receiving the Charité disc prosthesis, most problems arose from degeneration of other lumbar discs, facet joint arthrosis at the same or other levels and subsidence of the prosthesis. The first two complications represent the problems that the device was designed to avoid. It is to be expected that many more patients will be seen with late problems, some years after this operation, as the survivorship will decrease with time. One difficulty with interpretation of this report is the lack of knowledge about the total number of artificial discs implanted. The implications are quite different if the 27 patients represent failures from 100 surgeries or failures from 10,000 surgeries.

As noted above, wear debris, a concern with polyethylene implants in the peripheral joints, is a concern with artificial intervertebral discs due to their proximity to the spinal canal and nerve roots. According to the manufacturer, in a long-term laboratory test of cyclical motion simulating more than 11 years of use, no wear debris particles were identified. However, there was almost no data in the literature describing patients at least 10 years after placement of the device.

**Summary**

The case series suggest that outcomes following placement of the Charité device are similar to those reported in the literature from case series of lumbar fusion. However, selection bias and the lack of controls make such interpretation weak. The case series are most useful in providing some data on the types of complications that can be expected, though these are incompletely reported.

The article describing the pivotal clinical trial did not provide enough detail to make any assessment of the quality of the trial. Allocation concealment, outcome assessment, loss to follow-up and statistical methods were not reported. The VAS and ODI scores suggest a trend towards better outcomes with the artificial disc after two years of follow-up. However, no data are presented on development or progression of disc degeneration at adjacent level, the main theoretical benefit from the improved range of motion afforded by the artificial disc. Moreover, the only complications reported are neurologic adverse events. These appear to be comparable in the two groups, but other adverse events
are not reported. The Dutch case series suggested that progression of adjacent disc disease remains a problem after placement of the artificial disc. Thus, it is not clear that the Charité Artificial Disc improves net outcomes.

**TA criterion 3 is not met.**

**TA Criterion 4: The technology must be as beneficial as any established alternatives.**

There is controversy surrounding the established treatment for refractory symptoms from degenerative disc disease. However, since the publication of the meticulously performed and reported Swedish randomized trial (Fritzell, Hagg et al., 2001), many back specialists consider spinal fusion to be the standard treatment. Indeed, all four of the U.S. trials of artificial disc replacement have spinal fusion as the control arm. Unfortunately, there is no consensus on the best technique for fusion. Each of the four trials uses a different fusion technique (BAK cage with autograft, 360° fusion with anterior femoral ring, LT-CAGE with infuse bone graft, 360° fusion with posterior approach).

The primary advantage over fusion offered by an artificial disc is the preservation of range of motion at the affected joint. This is intended to prevent hypermobility and accelerated degeneration at adjacent spinal levels. None of the published trials to date presented any evidence of a reduction in degeneration in adjacent discs. In the one poorly reported randomized trial (Geisler, Blumenthal et al., 2004), clinical outcomes and neurologic complication rates appear equivalent in the artificial disc and spinal fusion groups. However, long-term outcomes are still uncertain with this novel device. Given long-term uncertainty and no clear clinical advantages, the Charité Artificial Disc cannot be considered equivalent to spinal fusion.

**TA criterion 4 is not met.**

**TA Criterion 5: The improvement must be attainable outside the investigational setting**

The Charité Artificial Disc is also currently used in disc replacement surgery in more than 30 countries throughout Europe, Asia, North America, Africa and Latin America. According to the manufacturer, worldwide experience with this disc replacement device is now greater than 10,000 cases. However, there is clearly a learning curve to surgery using the Charité disc. In recognition of that fact, the U.S. clinical trial allowed for five device implantations at each surgical center prior to initiating randomization.

There are currently no well-defined, accepted standards for the training of surgeons wanting to employ the use of new technology. The manufacturer of the Charité Artificial Disc, DePuy Spine, has stated that prior to doing any surgery with the Charité disc, surgeons must undergo extensive training sponsored by DePuy Spine. This mandatory training includes a combination of participating in artificial disc surgery procedures with other trained surgeons, consultation and visitation with spine surgeons, and lectures and educational materials.
In addition, the Spinal Arthroplasty Society has set a goal of establishing standardized training programs for physicians prior to their using any new artificial disc replacement technology. It is intended that the training be similar to that required for participation in the FDA clinical trials. While such training is expensive and time consuming for both the surgeons and faculty, there are many important benefits for patients, surgeons, hospitals and manufacturers of the artificial disc.

However, given that no improvement has clearly been demonstrated in the investigational setting, no conclusions can be drawn regarding device effectiveness in the community setting.

TA criterion 5 is not met.
CONCLUSION

Four case series have been published describing the clinical outcomes for 215 patients who received the Charité Artificial Disc and were followed for a minimum of 18 months. Satisfactory clinical outcomes were reported for 63% to 79% of patients, which is comparable to reported success rates for lumbar fusion. However, uncontrolled case-series are the weakest form of evidence. Data from one randomized clinical trial of 304 patients comparing the artificial disc to spinal fusion have been published. Unfortunately, the incomplete reporting of the methods (no details on randomization, allocation concealment, perioperative complications, blinding of outcome assessment, follow-up, adverse events or statistical methods) gives the study a poor quality score. Improvements in pain and disability scores favored the artificial disc, but were of borderline statistical significance and may have been biased due to lack of blinding. The authors stated primary motivation for artificial disc replacement was to maintain range of motion in order to avoid initiating or accelerating degeneration in adjacent segments. However, no data were presented evaluating degeneration in adjacent discs. Additionally, reports in the literature clearly define device related complications from slippage, malpositioning and subsidence (sinking of the device into the adjacent vertebral body). Finally, many patients who receive an artificial disc will be relatively young, which means that the disc prosthesis must last 40 to 50 years. The long-term viability of the disc is unknown. Given the poor quality of the published literature and the uncertainties in the relative benefits and harms of the artificial disc compared with spinal fusion, further data are needed in order to determine whether the Charité Artificial Disc meets CTAF criteria.

Recommendation

It is recommended that the use of the Charité Artificial Disc does not meet Technology Assessment criteria 3, 4, or 5 for treatment of degenerative disc disease of the lumbar spine.

The CTAF panel voted unanimously to accept the recommendation as written.

February 16, 2005
RECOMMENDATIONS OF OTHERS

Blue Cross Blue Shield Association (BCBSA)
A BCBSA Technology Evaluation Center determined that the use of this technology does not meet TEC criteria.

Centers for Medicare and Medicaid Services (CMS)
A search of the CMS web site was conducted and there were no references to coverage determinations for artificial disc to be found. In 2004 CMS did implement ICD-9 coding for the use of artificial discs.

California Orthopaedic Association (COA)
The COA attended the meeting but did not provide a formal opinion or position statement.

California Association of Neurological Surgeons (CANS)
A CANS representative did not attend the meeting. However, CANS did provide a statement in support of the artificial disc as a treatment alternative for appropriate patients with DDD.

ABBREVIATIONS USED IN THIS ASSESSMENT:

PLIF: posterior lumbar interbody fusion
TLIF: transforaminal lumbar interbody fusion
ALIF: anterior lumbar interbody fusion
FDA: Food and Drug Administration
DARE: Database of Abstracts of Reviews of Effects
VAS: visual analog scale
ODI: Oswestry Disability Index
RCT: Randomized Controlled Trial
CT: Computed Tomography
MRI: Magnetic Resonance Imaging
REFERENCES


