

Technical Monograph

BRYAN[®] Cervical Disc Prosthesis

A Six Month to Two Year Analysis from an Ongoing Clinical Study of Single and Bi-Level Cases

J. Goffin, M.D., Ph.D.
F. Van Calenbergh, M.D.
J. van Loon, M.D.
Universitaire Ziekenhuizen Leuven
Leuven, Belgium

A. Casey, M.D.
National Hospital for Neurology & Neurosurgery
London, England

P. Kehr, M.D.
Centre de Trauma et d'Ortho
Illkirch, France

K. Liebig, M.D.
Waldkrankenhaus St. Marien
Erlangen, Germany

B. Lind, M.D., Ph.D.
Sahlgrenska University Hospital
Göteborg, Sweden

C. Logroscino, M.D.
R. Sgrambiglia, M.D.
Universita' Cattolica-Roma
Rome, Italy

V. Pointillart, M.D., Ph.D.
Hôpital Tripode
Bordeaux, France

Bryan[®]
Cervical Disc System

May 2003

SUMMARY – SINGLE LEVEL

Eighty-three out of 92 patients (90%) evaluated at six-month follow-up, 76 out of 89 patients (86%) evaluated at one-year follow-up, and 44 out of 49 patients (90%) evaluated at two-year follow-up have met or exceeded the anticipated study success derived from literature (Odom's classification of excellent, good, or fair).

Postoperative Cobb angle measurements of the functional spinal unit at the implant level demonstrated motion of the device in flexion/extension averaging about 9.0° at two-year follow-up. No cases of device ankylosis or adjacent instability occurred.

INTRODUCTION

The concept that interbody fusion of the cervical spine leads to accelerated degeneration of adjacent disc levels due to increased stress from the fusion is widely postulated. Therefore, reconstruction of a failed intervertebral disc with a functional disc prosthesis should offer the same benefits as decompression and fusion while simultaneously maintaining physiological motion and kinematics, thereby protecting the adjacent level discs from the abnormal stresses associated with fusion.

The purpose of this study is to determine if a unique, functional, intervertebral cervical disc prosthesis can provide relief from objective neurological symptoms and signs, improve patient function, decrease pain, and provide motion. This report reviews data received as of January 17, 2003. Follow-up is provided for patients at six months, one year, and two years.

METHODS AND MATERIALS

Device Description

The BRYAN® Cervical Disc prosthesis is a cervical intervertebral disc prosthesis designed to permit motion similar to the normal cervical functional spine unit. The prosthesis is intended to treat stable cervical degenerative disc disease without fusion, thereby providing the capability for maintaining motion at the treated level.

The device consists of a polyurethane nucleus designed to fit between two titanium alloy surfaces (shells). The bone-contacting surface of each shell includes a titanium porous coating to facilitate bony ingrowth and long-term stability. A polyurethane sheath surrounds the nucleus and is attached to the shells, forming a closed compartment. Titanium alloy seal plugs provide for retention of a lubricant. Anterior stops on each shell are designed to prevent posterior migration of the device, and aid prosthesis insertion.

The prosthesis is presently configured in five diameters: 14, 15, 16, 17, and 18 mm.



FIGURE 1: BRYAN® CERVICAL DISC PROSTHESIS

Study Design

Patients were concurrently enrolled in a multi-center evaluation of the prosthesis for the treatment of single-level degenerative disc disease of the cervical spine. The prospective study was approved by the ethics committee and, as required, the regulatory agencies for each center. Patient inclusion criteria consisted of disc herniation or spondylosis, with radiculopathy and/or myelopathy, which had not responded to conservative treatment. Exclusion cri-

teria included previous cervical spine surgery involving any other device, axial neck pain as the solitary symptom, significant cervical anatomical deformity or clinical instability, and active infection.

Patient assessments are performed at pre-op, post-op, six weeks, three months, six months, one year and two years. The primary endpoint is classification based on relief of preoperative symptoms (as assessed by the patient using the Cervical Spine Research Society and SF-36 Patient Questionnaires) and relief of objective neurological signs (as assessed by the physician in a neurological examination) associated with the treated level. Patient data was entered into a database. Results were scored according to a modified Odom's Criteria and categorized as indicated in Table 1.

TABLE 1: SCORING CRITERIA

Excellent:	improvement in most (at least 80%) of the preoperative signs and symptoms, with little deterioration (not more than 10%)
Good:	improvement in some (at least 70%) of the preoperative signs and symptoms, with some deterioration (not more than 15%)
Fair:	improvement in half (at least 50%) of the preoperative signs and symptoms, with some deterioration (not more than 20%)
Poor:	improvement in few (less than 50%) of the preoperative signs and symptoms, or significant deterioration (more than 20%)

Radiographs were analyzed independently to determine range of motion and assess device migration and/or subsidence.

Study Enrollment

A total of 103 devices were implanted. In all cases, neural compression was verified using CT or MRI. Neurological assessment was coordinated with the compressive pathology. All of the 103 patients have been followed for six months, 100 patients have been followed for one year, and 51 patients have been followed for two years. Table 2 details the demographic variables of the patients.

The duration of preoperative symptoms ranged from three weeks to greater than two years. The primary diagnosis was herniation with radiculopathy in 60%, spondylosis with radiculopathy in 18%, herniation with myelopathy in 4%, spondylosis with myelopathy in 3%, and multiple symptoms in 15%.

TABLE 2: PATIENT DEMOGRAPHICS (103)

Age Range	26 to 79				
Gender	Male 42		Female 61		
Clinical Diagnosis	Radiculopathy 96		Myelopathy 14		
Levels Implanted	C3-C4 0	C4-C5 11	C5-C6 41	C6-C7 51	
Size Implanted	14mm 25	15mm 23	16mm 25	17mm 21	18mm 9

OPERATIVE TECHNIQUE

Following initial discectomy, surgical instruments utilize a simple gravitational referencing system to establish a virtual axis in the intervertebral disc space that is used to position a milling fixture.

This fixture precisely controls the powered cutting instruments that prepare the vertebral endplates for placement of the prosthesis. The milled vertebral endplates match the geometry of the implant's convex outer surface, capturing the rim of each shell inside a ridge of bone. This tight fit provides immediate A/P and lateral stability.

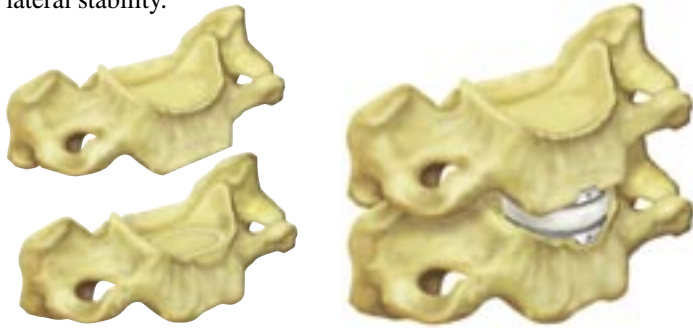


FIGURE 2: MILLED VERTEBRAL BODIES AND FINAL CONSTRUCT

OPERATIVE TIMES

Operative times for the procedure were calculated after removing the time of the first two surgeries for each investigator to account for surgeon training.

Table 3 displays all reported operative times for the BRYAN® implant procedure as averaged with one standard deviation (SD). The times for ACDF autograft, modified cage with plate (TSM: titanium surgical mesh), and the cervical cage, as published in Hacker¹ and Castro² are provided for comparison.

TABLE 3: COMPARISON OF LENGTH OF SURGERY

Average Minutes (SD)

BRYAN® Prosthesis	ACDF with Iliac Autograft	TSM Cage With Plate	Cervical Cage
125 (51)	180 (14)	132 (6)	92 (*)

* Standard deviation not published.

HOSPITAL LENGTH OF STAY

The total number of days from surgery to discharge ranged from one to ten. The average was 3.5 days with a standard deviation of 2.0 days. Table 4 provides a site-to-site comparison of the post-surgery length of stay (surgery to discharge). Length of stay varies by country and hospital, in accordance with local standards. No restrictive postoperative management has been found to be necessary.

TABLE 4: SITE-TO-SITE COMPARISON OF LENGTH OF STAYS

Average Days (SD)

All Sites	Belgium	Germany	France (#1)	England	Italy	Sweden	France (#2)
3.5 (2.2)	4.4 (1.5)	10.0 (0)	4.9 (1.1)	2.1 (0.8)	2.2 (0.8)	3.1 (1.1)	1.1 (0.2)

CLINICAL RESULTS

Neurological Symptoms and Signs

Of the 92 patients with complete clinical data at the six-month follow-up, 83 (90%) were classified as excellent/good/fair. At the one-year follow-up, the scores were excellent/good/fair for 76 out of 89 (86%) of the patients. Of the 49 patients with complete

clinical data at two-year follow-up, 44 (90%) were classified as excellent/good/fair. This result is greater than the targeted success rate of 85% excellent/good/fair, based on a statistical analysis of literature data. Eleven patients at the six-month follow-up, 11 patients at the one-year follow-up, and two patients at the two-year follow-up had either incomplete scores or missed follow-up and were not included in the calculations.

Table 5 summarizes clinical results for the 49 patients with complete clinical data at two-year follow-up. Outcomes at two years are compared to the patients' one-year results. The diagonal shaded line 33/49 (67%) of patients maintained their clinical status from the one-year to the two-year follow-up. An equal number of patients 8/49 above the diagonal improved their outcome as compared to those below the line who did worse. This result can be attributed to variances in the scoring system.

TABLE 5: SUMMARY OF CLINICAL RESULTS

49 Patients Scored	Excellent at 1 Year	Good at 1 Year	Fair at 1 Year	Poor at 1 Year
Excellent at 2 Years	26	2	3	1
Good at 2 Years	2	0	0	0
Fair at 2 Years	3	1	4	2
Poor at 2 Years	1	0	1	3

COMPLICATIONS

There were three re-interventions at the treatment level. They included an evacuation of a prevertebral hematoma, a posterior foraminotomy without device involvement to treat residual symptoms and a posterior decompression to treat residual myelopathic symptoms. Regarding the residual myelopathy complication, the patient's preoperative duration of symptoms was more than two years prior to the initial surgery, and the re-intervention was not performed by one of the study investigators. In one patient, the wrong level was initially operated on, with a subsequent report of unresolved pain that was corrected by follow-up surgery in which a second device was implanted at the targeted level. After the second operation, temporary dysphonia occurred. One patient reported pain in the right shoulder, right arm, and in the sternum region approximately six months after surgery. An MRI ruled out any remaining neural compression. Another patient remarked about unresolved non-specific shoulder pain on the left side. One patient in the single level study required a second device implant at an adjacent level 21 months after the initial surgery because of radiculopathy due to disc herniation. After the second surgery, which was performed with an approach from the opposite side, the patient experienced severe dysphonia due to bilateral vocal cord paralysis. The investigator attributed it to bilateral recurrent nerve compression resulting from excessive retraction.

There have been no device failures or device explantations.

RADIOGRAPHIC RESULTS

Radiographic follow-up data has been obtained for 89 patients at six months, 90 patients at one year and 46 patients at two years. An independent radiologist assesses all radiographs.

Device Position

Device positioning is measured in lateral radiographs at each follow-up interval. Subsidence has not been observed in any patients. Evidence of anterior/posterior device migration was detected in one patient; however, migration greater than 3mm has not been

observed in any patients. This threshold is based on the accuracy of measuring plain radiographs.

Range of Motion Results

Postoperative Cobb angle measurements of the functional spinal unit (FSU) at the implant level demonstrated motion of the device in flexion/extension. The range of motion for patients at six months averages 8.3° with a standard deviation of 4.5°. Eighty-six out of 89 patients, (97%) demonstrated flexion/extension range of motion equal to or greater than 2°. Two degrees is the threshold that clearly establishes motion without question of measurement error due to radiographic image magnification and/or distortion.

The range of motion for patients at one year averages 7.9° with a standard deviation of 5.3°. Seventy-nine out of 90 patients, (88%) demonstrated flexion/extension range of motion equal to or greater than 2°. The range of motion for patients at two years averages 9.0° with a standard deviation of 4.9°. Forty-three out of 46 patients (93%) demonstrated flexion/extension range of motion equal to or greater than 2°.



FIGURE 3: PREOPERATIVE RANGE OF MOTION

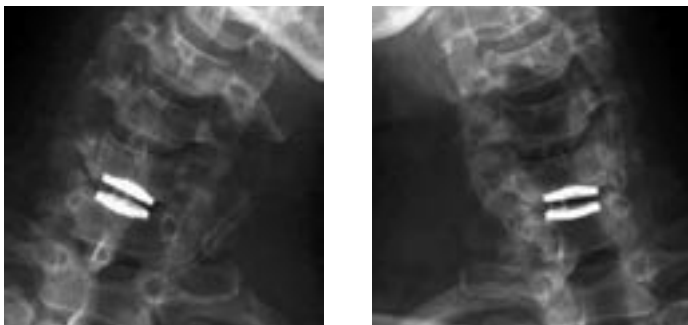


FIGURE 4: THREE-MONTH RANGE OF MOTION



FIGURE 5: TWELVE-MONTH RANGE OF MOTION

QUALITY OF LIFE RESULTS

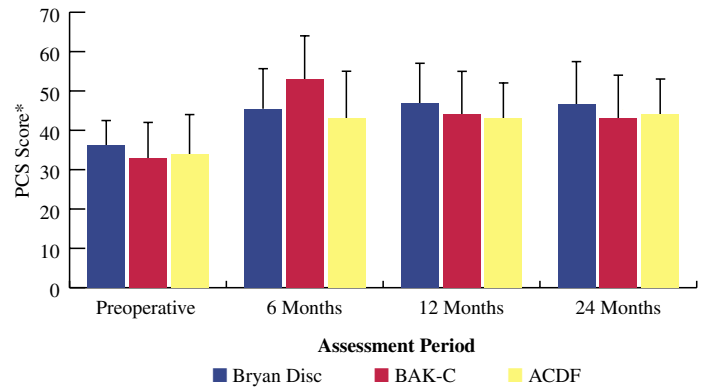
SF-36 Health Survey results are presented for the patients reaching the six-month, one-year and two-year follow-up periods. Values for each period are presented in the SF-36 Physical

Component Summary (PCS) and Mental Component Summary (MCS) scores, which utilize U.S. population means to establish normalized scores.

Results for PCS and MCS scores are comparable to results published for single-level fusion and cervical cage subjects in a prospective randomized study conducted for the cervical cage.¹ In Figure 6, the results for all patients who reached six-month, 12-month and/or 24-month follow-up are averaged and compared to patients in the cervical cage study and to those who received an autograft/allograft fusion. At 24 months post-implant, patient average for the BRYAN® prosthesis met or exceeded the U.S. population mean for PCS and MCS scores.

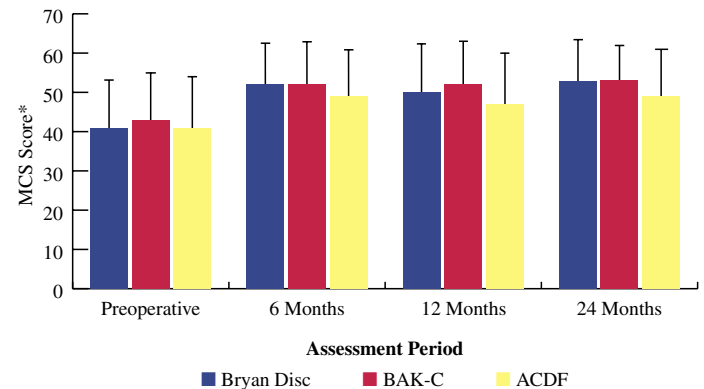
PHYSICAL COMPONENT SUMMARY

U.S. Population Mean = 50 (SD10)



MENTAL COMPONENT SUMMARY

U.S. Population Mean = 50 (SD10)



*Average with one standard deviation.

Figures for the Cervical Cage and ACDF groups are approximations based on bar charts presented.

FIGURE 6: COMPARISON OF SF-36 SUMMARY SCORES

CONCLUSIONS

Forty-four out of 49 patients (90%) evaluated at the two-year follow-up, 76 out of 89 patients (86%) evaluated at one-year follow-up, and 83 out of 92 patients (90%) evaluated at six-month follow-up were deemed a clinical success (Odom's classification of excellent, good, or fair). At two years, the BRYAN® prosthesis has a success rate greater than 85%, with 95% confidence.

The data clearly shows that devices do not migrate, and the device allows for segmental motion. The implantation of the device alleviates pain and improves function based on neurological signs and symptoms at least equivalent to ACDF.

SUMMARY – BI-LEVEL

Twenty-eight out of 34 patients (82%) evaluated at six-month follow-up and 25 out of 26 patients (96%) evaluated at one-year follow-up can be judged a clinical success (Odom’s classification of excellent, good, or fair).

Postoperative Cobb angle measurements of the functional spinal unit at the implant level demonstrated motion of the device in flexion/extension averaging about 7.4° at one-year follow-up. No cases of device ankylosis or adjacent instability occurred.

Study Enrollment

A total of 86 devices were implanted. In all cases, neural compression was verified using CT or MRI. Neurological assessment was coordinated with the compressive pathology. Forty-one of the patients have been followed for six months, and 30 patients have been followed for one year. Table 6 details the demographic variables of the patients.

The duration of pre-operative symptoms ranged from less than six weeks to greater than two years. The primary diagnosis was herniation with radiculopathy in 5%, spondylosis with radiculopathy in 58%, herniation with myelopathy in 2%, spondylosis with myelopathy in 7%, and multiple symptoms in 28%.

TABLE 6: PATIENT DEMOGRAPHICS (43)

Age Range	28 to 62				
Gender	Male 25			Female 18	
Clinical Diagnosis	Radiculopathy 38			Myelopathy 10	
Levels Implanted (1st Level)	C3-C4 0	C4-C5 8	C5-C6 35	C6-C7 0	
Levels Implanted (2nd Level)	C3-C4 0	C4-C5 0	C5-C6 8	C6-C7 35	
Size Implanted	14mm 11	15mm 18	16mm 24	17mm 20	18mm 13

CLINICAL RESULTS

Neurological Symptoms and Signs

Of the 34 patients with complete clinical data at the six-month follow-up, 28 (82%) were classified as excellent/good/fair. At one year the scores were excellent/good/fair for 25 out of 26 (96%) of the patients.

Table 7 summarizes clinical results for the 23 patients with complete clinical data at one-year and six-month follow-ups. Outcomes at one year are compared to the patients’ six-month results. The diagonal shaded line 14/23 (61%) of patients maintained their clinical status from six months to their one-year follow-up. 9/23 patients above the diagonal improved over this time period while no patients did worse. This result can be attributed to variances in the scoring system and will probably achieve a more normal distribution at later follow-up periods.

TABLE 7: SUMMARY OF CLINICAL RESULTS

23 Patients Scored	Excellent at 6 Months	Good at 6 Months	Fair at 6 Months	Poor at 6 Months
Excellent at 1 Year	12	2	3	0
Good at 1 Year	0	0	0	1
Fair at 1 Year	0	0	1	3
Poor at 1 Year	0	0	0	1

COMPLICATIONS

One patient experienced a cerebral spinal fluid (CSF) leak while decompressing posteriorly. In addition, there were four re-interventions at the treatment level that included an evacuation of an epidural hematoma, an evacuation of a prevertebral hematoma, a repair of a pharyngeal tear/esophageal wound incurred during intubation, and an anterior decompression due to ongoing nerve root compression. This last re-intervention required revision surgery for decompression of residual foraminal stenosis, and the device was repositioned.

RADIOGRAPHIC RESULTS

Radiographic follow-up data has been obtained for 38 patients at six months and 26 patients at one year. Data was unavailable for several levels due to obscured radiographs at lower levels; therefore, results are reported by level. An independent radiologist assesses all radiographs.

Device Position

Device positioning is measured in lateral radiographs at each follow-up interval. Subsidence has not been observed in any patients. Evidence of anterior/posterior device migration was detected in one patient; however, migration greater than 3mm has not been observed in any patients. This threshold is based on the accuracy of measuring plain radiographs.

Range of Motion Results

Postoperative Cobb angle measurements of the functional spinal unit (FSU) at the implant level demonstrated motion of the device in flexion/extension. The range of motion for patients at six months averages 7.3° with a standard deviation of 4.1°. Seventy-two out of 73 levels, or 99%, demonstrated flexion/extension range of motion equal to or greater than 2°. Two degrees is the threshold that clearly establishes motion without question of measurement error due to radiographic image magnification and/or distortion.

The range of motion for patients at one year averages 7.4° with a standard deviation of 5.1°. Forty-two out of 49 levels, or 86%, demonstrated flexion/extension range of motion equal to or greater than 2°.



FIGURE 7: BI-LEVEL FINAL CONSTRUCT

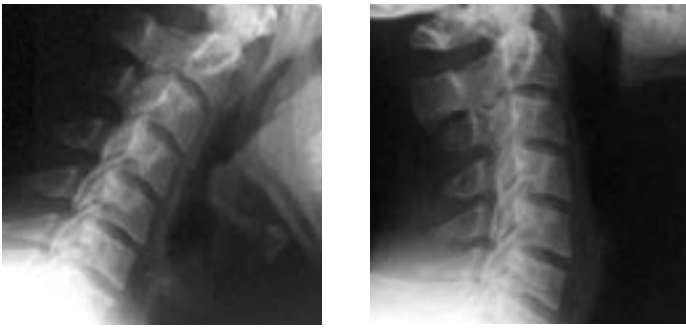


FIGURE 8: PRE-OPERATIVE RANGE OF MOTION

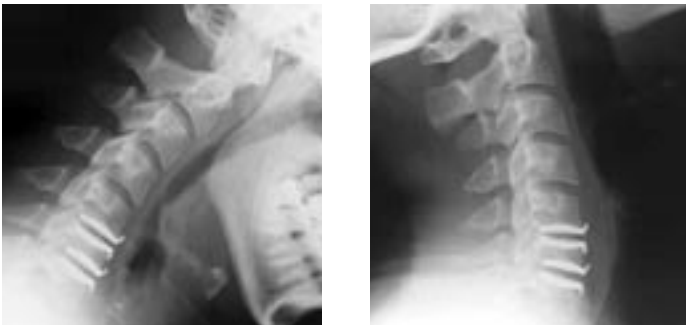


FIGURE 9: THREE-MONTH RANGE OF MOTION

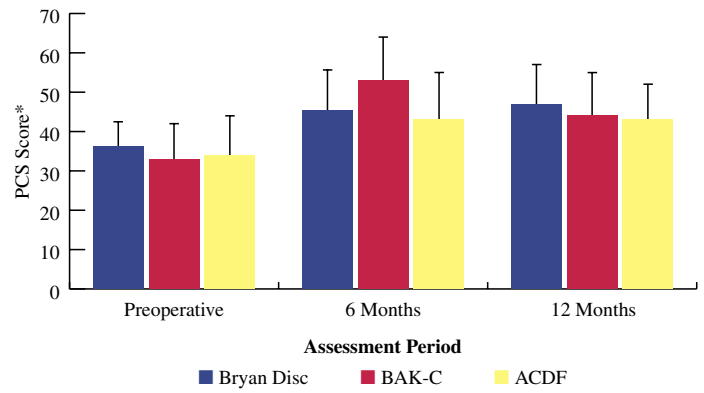
QUALITY OF LIFE RESULTS

SF-36 Health Survey results are presented for the patients reaching the six-month and one-year follow-up periods. Values for each period are presented in the SF-36 Physical Component Summary (PCS) and Mental Component Summary (MCS) scores, which utilize U.S. population means to establish normalized scores.

Results for PCS and MCS scores are comparable to results published for single-level fusion and cervical cage subjects in a prospective randomized study conducted for the cervical cage.¹ In Figure 10, the results for all patients who reached six-month and 12-month follow-up are averaged and compared to patients in the cervical cage study and to those who received an autograft/allograft fusion.

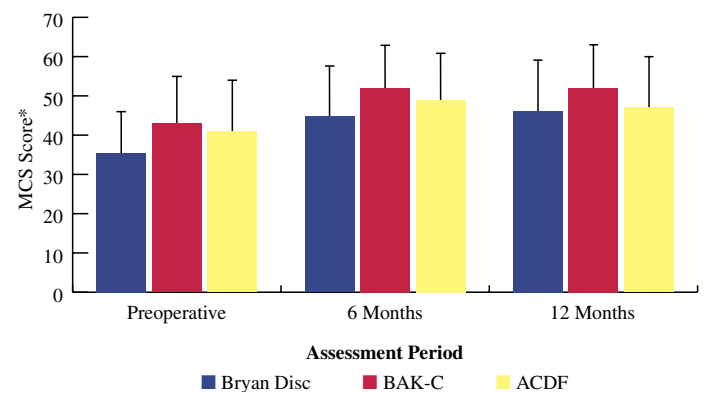
PHYSICAL COMPONENT SUMMARY

U.S. Population Mean = 50 (SD10)



MENTAL COMPONENT SUMMARY

U.S. Population Mean = 50 (SD10)



*Average with one standard deviation.

Figures for the Cervical Cage and ACDF groups are approximations based on bar charts presented.

FIGURE 10: COMPARISON OF SF-36 SUMMARY SCORES

CONCLUSIONS

Twenty-five out of 26 patients (96%) evaluated at one-year follow-up and 28 out of 34 patients (82%) evaluated at six-month follow-up were deemed a clinical success (Odom’s classification of excellent, good, or fair).

The data clearly shows that devices do not migrate, and the device allows for segmental motion. The implantation of the device alleviates pain and improves function based on neurological signs and symptoms at least equivalent to ACDF.

REFERENCE DOCUMENTS

¹R.J. Hacker et al, “A Prospective Randomized Multicenter Clinical Evaluation of an Anterior Cervical Fusion Cage,” Spine, Vol. 25, No 20, pp 2646-2655.

²F.P. Castro et al, “A Cost Analysis of Two Anterior Cervical Fusion Procedures,” Journal of Spinal Disorders, Vol. 13, No. 6, pp 511-514.

