NATIONAL INSTITUTE FOR CLINICAL EXCELLENCE

INTERVENTIONAL PROCEDURES PROGRAMME

Interventional procedures overview of prosthetic intervertebral disc replacement of the cervical spine

Introduction

This overview has been prepared to assist members of the Interventional Procedures Advisory Committee (IPAC) in making recommendations about the safety and efficacy of an interventional procedure. It is based on a rapid review of the medical literature and specialist opinion. It should not be regarded as a definitive assessment of the procedure.

Date prepared

This overview was prepared in February 2005.

Procedure name

- Prosthetic intervertebral disc replacement of the cervical spine.

Specialty societies

Specialist advice was sought from:

- British Association of Spinal Surgeons
- British Cervical Spine Society.

Description

Indications

This treatment may be suitable for patients with degenerative disc disease, either for acute disc herniation or spondylotic disease. These are conditions in which nerve root or spinal cord compression may cause symptomatic radiculopathy or myelopathy.

Current treatment and alternatives

Conservative treatment options for acute radicular pain include analgesic medication, rest, supervised physical therapy such as physiotherapy etc, and local injections.

Surgical intervention is reserved for cases with neurological threat, or failure to settle with conservative care. The standard treatment is surgical decompression of the nerve root or spinal cord by cervical discectomy with or without fusion (using iliac crest autograph or a variety of preformed spacers/cages).

Following anterior cervical discectomy, a proportion of patients represent with progressive spondylosis requiring surgical treatment at adjacent cervical segments. Reconstruction of a failed intervertebral disc using a functional prosthesis aims to

offer the same benefit as decompression whilst preserving motion at the operated segment thereby reducing abnormal stresses on adjacent disc levels associated with fusion procedures.

What the procedure involves

Artificial intervertebral discs have been developed to act as a functional prosthetic replacement unit for intervertebral units in much the same way as prostheses have been developed for a variety of joints such as the hip or knee. A number of devices have been developed for the cervical spine Under general anaesthetic the patient is placed in the supine position. The anterior cervical spine is exposed, and after standard decompression of the neural elements, an artificial disc prosthesis is placed between the vertebrae, instead of no prosthesis or a graft.

Efficacy

Many studies rely on patients' self-reported outcomes to determine clinical efficacy of prosthetic disc implants.

In two randomised controlled trials of artificial disc implants, with follow-up to 6 and 24 months, neck and arm pain scores, and quality of life indices all improved compared with baseline scores, with no statistically significant difference in outcomes compared to patients treated by fusion surgery. One case series found significant improvements in arm and neck symptom scores and neck disability index assessment at 6 months compared with preoperative values, and a second series found a statistically non-significant improvement in pain outcomes at 24 months.

The largest series available reported an improvement in a composite outcome of clinical evaluation of motor strength and sensory signs, and reported patient self-evaluation of symptoms as 'excellent' in 65% (32/49) of patients having disc replacement at one level, and 77% (20/26) of patients having bi-level surgery.

Where reported, the range of motion in the segment where the prosthesis was placed was determined to be well preserved. One case series reported motion of more than 2 degrees, confirmed by radiographic assessment, in 93% (43/46) of patients treated. A second series reported motion of 7.5 degrees at baseline and 6.5 degrees at 24-month follow-up. Maintenance of a 5.9 degree range of motion at 12-month follow-up was demonstrated in the prosthetic disc arm of a randomised controlled trial; however, there was no statistically significant difference in motion at adjacent levels compared with a group treated with fusion.

Following artificial disc replacement residual neck pain was reported by 22.5% (6/27) of patients in the active arm of one randomised controlled trial and both continuous neck pain, and continuous shoulder pain was reported by 4% (1/27) of patients. In a case series persistent radicular pain was noted by 13% (2/15) of patients 24 months postoperatively.

Safety

There were no reported incidents of device failure in 27 cases in the prosthetic implant arm of a randomised control trial, or among 13 patients in a case series. Device migration was noted in 2% (2/103) of patients undergoing prosthetic cervical disk implant in a case series, although no migration was greater than 3.5 mm from the initial implant site.

In a large case series of patients undergoing prosthesis implant, reintervention was required in 3% (3/103) of patients, two patients to treat residual symptoms, and one patient for evacuation of a haematoma.

Other adverse events reported include transient hoarseness 13% (2/15), moderate dysphagia 4% (1/27), and recurrent laryngeal nerve palsy 4% (1/27).

Literature review

Rapid review of literature

The medical literature was searched to identify studies and reviews relevant to Prosthetic intervertebral cervical disc replacement Searches were conducted via the following databases, covering the period from their commencement to 23 February 2005: MEDLINE, PREMEDLINE, EMBASE, Cochrane Library and Science Citation Index. Trial registries and the Internet were also searched. No language restriction was applied to the searches.

The following selection criteria (Table 1) were applied to the abstracts identified by the literature search. Where these criteria could not be determined from the abstracts the full paper was retrieved

Table 1 Inclusion criteria for identification of relevant studies

Characteristic	Criteria
Publication type	Clinical studies included. Emphasis was placed on identifying good quality studies. Abstracts were excluded where no clinical outcomes were reported, or where the paper was a review, editorial, laboratory or animal study. Conference abstracts were also excluded because of the difficulty of appraising methodology.
Patient	Patients with radiculopathy or myelopathy as a result of degenerative disc disease or spinal cord compression.
Intervention/test	Prosthetic intervertebral disc replacement.
Outcome	Articles were retrieved if the abstract contained information relevant to the safety and/or efficacy.
Language	Non-English-language articles were excluded unless they were thought to add substantively to the English-language evidence base.

List of studies included in the overview

This overview is based on two randomised controlled trials and three case series (see Table 1).

Existing reviews on this procedure

No published systematic review or evidence-based guidelines on this procedure were found during literature searches.

Table 1 Summary of key efficacy and safety findings on prosthetic intervertebral disc replacement of the cervical spine

Study details	Key efficacy findings	Key safety findings	Comments
Sekhon L H S (2003)(1) Case series (all patients requested the device when surgical options were discussed) Australia n = 7 Inclusion criteria: patients with spinal cord compression and or had cervical myelopathy. Exclusion criteria included multi level spondylotic disc degeneration, and spinal cord injury Mean age = 43 years, Male = 57%, symptoms persistent for 16 months (range 0.75 - 72 months) Method used: Bryan disc Follow up 6 months (range 1 - 17 months) Measures included a neurological examination and Nurick grading, patients completed an Oswestry neck disability index assessment, and scored symptoms from 0 to 3 (none to severe) All outcomes reported are for most recent follow-up achieved	**Symptom improvement** Neck symptom scores improved from 1.71 ± 0.29 at baseline to 0.43 ± 0.30 ($p < 0.01$) Arm Symptom scores improved from 2.00 ± 0.49 at baseline to 0.29 ± 0.29 ($p < 0.001$) The Oswestry neck disability index improved from 56.9 ± 6.8 at baseline to 5.40 ± 2.30 ($p<0.0001$) **Clinical improvement** There was a significant improvement on clinical patient assessment with the Nurick grade falling from 1.71 ± 0.36 to 1.00 ± 0.00 ($p < 0.05$) All patients demonstrated a good range of cervical motion as assessed by fluoroscopic screening at the last postoperative assessment All patients had a good or excellent operative outcome (either 'minimum persistence of preoperative symptoms able to carry out daily occupation without significant interference', or 'all preoperative symptoms relieved, able to carry out daily occupations without impairment')	**All adverse events** There were on complications or deaths in the intraoperative or postoperative period	Symptom score measure not validated. Self-selected patient cohort. Single operator undertook all interventions. It is unclear how many cases had reached each follow-up assessment period. The authors note that treatment by multilevel disc replacement requires further investigation.

<table>
<tr><th>Study details</th><th>Key efficacy findings</th><th>Key safety findings</th><th>Comments</th></tr>
<tr>
<td>Sasso R C (2004)(2)

Abstract – early single-centre results from an FDA investigational device exemption study RCT

USA

n = 13

Method used:
• Bryan artificial disc = 6
• anterior cervical discectomy and fusion = 7

6 months follow up</td>
<td>Patient reported outcomes
Neck pain visual analogue score
<table>
<tr><td></td><td>Baseline</td><td>6 months</td></tr>
<tr><td>Bryan disc</td><td>71</td><td>30</td></tr>
<tr><td>Fusion</td><td>84</td><td>41</td></tr>
</table>
(all data read from figures presented)

Arm pain visual analogue score
<table>
<tr><td></td><td>Baseline</td><td>6 months</td></tr>
<tr><td>Bryan disc</td><td>75</td><td>21</td></tr>
<tr><td>Fusion</td><td>80</td><td>21</td></tr>
</table>
(all data read from figures presented)

SF-36
<table>
<tr><td></td><td>Baseline</td><td>6 months</td></tr>
<tr><td>Bryan disc</td><td>32</td><td>45</td></tr>
<tr><td>Fusion</td><td>33</td><td>47</td></tr>
</table>
(all data read from figures presented)

The functional outcome data with the artificial disc closely mirrors the control group

Operative success
No device failure reported or explants occurred.</td>
<td>Adverse events
There have been no intraoperative or postoperative complications to date</td>
<td>Single-centre results from a multi-centre trial.

One operator only.

No details of randomisation reported in the abstract.

Small fraction of cohort through to 6 months follow-up thus far.

Potential benefits of movement against adjacent level may require longer follow-up to evaluate.</td>
</tr>
</table>

Study details	Key efficacy findings	Key safety findings	Comments
Goffin J (2003)(3) Case series – consecutive patients International multicentre n = 146 (103 single level prosthesis, 43 bi-level) Patients with degenerative disc disease, either disc herniation or spondylosis with radiculopathy or myelopathy Age =26 - 79 years, Male =46% Method used: Bryan Disc Assessment by 40 neurologic tests, and subjective patient assessment of 15 symptoms. • Excellent = improvement in 80% of signs and symptoms • Good = improvement in 70% of signs and symptoms • Fair = improvement in 50% of signs and symptoms • Poor = improvement in less than 50% of signs and symptoms Follow-up: single level to 24 months, bi-level to 12 months	**Symptoms and signs** Improvements in surgeons assessment of motor strength, reflex, and sensory signs, and patient reported symptoms were recorded as follows Single level: Excellent 65% (32/49); Good 4% (2/49); Fair 21% (10/49); Poor 10% (5/49) Bi-level: Excellent 77% (20/26); Good 4% (1/26); Fair 15% (4/26); Poor 4% (1/26) **Operative data** Operative time for the single level procedure was 125 ± 51 minutes, and for bi-level surgery 158 ±53 minutes. The length of stay of patients undergoing the procedures was 3.5 ± 2.2 days following single level surgery, and 3.6 ± 6.2 days for bi-level surgery. **Range of motion**. The flexion and extension range of motion was greater than 2 degrees, in 93% (43/46) of patients following single level disc replacement, and 86% (42/49) patients having bi-level surgery **Quality of life assessment** The SF-36 health survey (physical component) showed baseline scores in the single level group to be 36.1 ± 6.4, and at 24 months postoperatively 46.8 ± 10.9. For the bi-level replacement groups the scores were 37.4 ± 7.2 at baseline and 47.0 ± 10.7 at 12 months.	**Surgical complications** Following single level surgery reintervention were required in 3% (3/103) of cases. This was for evacuation of a prevertebral haematoma, posterior foraminotomy for residual symptoms, and posterior decompression to treat residual myelopathic symptoms In the bi-level study there was a cerebral spinal fluid leak during decompression surgery in 2% (1/43) of cases, and reintervention was required in 9% (4/43) of cases. These were an evacuation of epidural haematoma, and of prevertebral haematoma, repair of a pharyngeal tear from intubation, and anterior decompression for ongoing nerve root compression. **Device position** There was no instance of device subsidence into the vertebral endplates Device migration was found in 2% (2/103) of patients undergoing single level disc replacement and 2% (1/43) of patients having artificial discs placed at two levels. However no migration greater than 3.5 mm was reported	Operative time was calculated from the 3rd and subsequent cases at each centre. Authors state that 5-year follow-up is necessary to evaluate long term performance of the prosthesis. No data provided regarding comparative efficacy between participating sites. Small number of patients through to 24-month follow-up in single level group, or 12-month follow-up in bi-level group. Careful patient selection used, with those included having failed on conservative treatment for at least 6 weeks, and exclusion of patients with instability, or previous spinal surgey.

Study details	Key efficacy findings	Key safety findings	Comments
Wigfield C C (2002)(4) Case series UK n = 15 Patients with radiculopathy or myelopathy, and CT or MRI evidence of compression by osteophytes or herniated disc material Age = 48 years, Male = 67%, duration of symptoms = 5 years Method used: Frenchay artificial cervical joint (prestige I) Neurologic examination by a clinician not involved in study, radiological assessment of motion by an independent radiooolgist, and patient questionnaires at baseline and all follow-up points Follow-up 24 months	**Operative data** Operative time for the procedure was 143 ± 48 minutes. **Motion preservation** The mean angulation of motion segment was 7.5 degrees (range 1-15 degrees) at baseline, and this was maintained following surgery as 6.5 degrees (range 3-12 degrees) **Symptomatic improvement** Patient self reported scores Baseline / 24 months / % improvement Arm pain: 6.1 / 3.25 / 46 Neck pain: 6.4 / 3.5 / 45 Neck disability index: 43.3 / 29.7 / 31 SF-36 physical: 32.2 / 36.7 / 14 SF-36 mental: 44.1 / 45 / 2 European Myelopathy scale: 14.4 / 15.3 / 6 No changes were statistically significant	**Surgical complications** Transient hoarseness 13% (2/15) Wound infection 0% Blood loss (mean) 316 ml Blood loss (median) 50 ± 662 ml **Device Stability** Screw failure 3% (2/60) Joint dislocation 0% **Clinical events** Persistent radicular pain 13% (2/15) Neck pain on full extension 7%(1/15) Continued myelopathy 7% (1/15) One patient reported neck pain on full extension and subsequently had the joint removed and fused. The artificial joint was found to be loose	Small sample size, and one case where the joint was excised was not included in all outcome assessment. The stainless steel design of the joint limited MRI assessment because imaging contained considerable artefact. Authors offer caution over subjective patient self assessment due to the fact that many of the patients have had a long history of chronic neck problems. A wide patient cohort, some of whom have had previous neck surgery.

<table>
<tr><th>Study details</th><th>Key efficacy findings</th><th>Key safety findings</th><th>Comments</th></tr>
<tr>
<td>Porchet F (2004)(5)

Randomised controlled trial

International multi-centre study (4 sites)

n = 55 (Prestige II = 27, Discectomy and fusion with iliac crest autograft = 28). Computer generated allocation at 1:1

Patients with single level degenerative disc disease with intractable radiculopathy or myelopathy. Neck disability index score > 30

Mean age = 44 years, Male = 53% (no significant difference in demographic variables between groups at baseline)

Method used: Prestige II disc

Follow-up 12 months n = 37, 24-months n = 9</td>
<td>Radiographic assessment of motion
Independent radiologists assessed X-ray films of 22 patients in the prestige II group and 14 patients in the fusion group at 12 months to determine motion at the treated level (mean scores)
<table>
<tr><td></td><td>Baseline</td><td>12 months</td></tr>
<tr><td>Prestige II</td><td>5.9 degrees</td><td>5.9 degrees</td></tr>
<tr><td>Fusion</td><td>6.3 degrees</td><td>1.1 degrees</td></tr>
</table>
No statistical differences were seen in adjacent level motions at 12 months

Self reported functional and pain outcomes
At 24 months both groups showed improvement in neck disability index score from baseline and the was statistical significance between the two groups

Each group demonstrated a statistically significant improvement in neck pain frequency and intensity compared to baseline scores

There was statistical equivalence in arm pain frequency and intensity score between the study groups.

Outcomes of the SF-36 questionnaire in both physical and mental components showed no statistical differences between the groups</td>
<td>Adverse events
<table>
<tr><td></td><td>Prestige II</td><td>Fusion</td></tr>
<tr><td>Total</td><td>63% (17/27)</td><td>68% (19/28)</td></tr>
<tr><td>Intermittent neck and / or arm pain</td><td>22% (6/27)</td><td>39% (11/28)</td></tr>
<tr><td>Continuous neck pain</td><td>4% (1/27)</td><td>11% (3/28)</td></tr>
<tr><td>Continuous shoulder pain</td><td>4% (1/27)</td><td></td></tr>
<tr><td>Myelopathy requiring reintervention</td><td></td><td>11% (3/28)</td></tr>
<tr><td>Malposition of disc</td><td>4% (1/27)</td><td></td></tr>
<tr><td>Recurrent palsy</td><td>4% (1/27)</td><td></td></tr>
<tr><td>Moderate dysphagia</td><td>4% (1/27)</td><td></td></tr>
<tr><td>Small graft</td><td></td><td>4% (1/28)</td></tr>
<tr><td>Contaminated graft</td><td></td><td>4% (1/28)</td></tr>
<tr><td>Haematoma</td><td></td><td>4% (1/28)</td></tr>
<tr><td colspan="3">No significant difference in the distribution of adverse events</td></tr>
</table>
No device failure was reported during follow-up</td>
<td>Small study with few patients through to 24 month follow-up, with subsequent low power to detect differences in efficacy parameters.

The intended benefits of the device through preservation of motion may take many years follow-up to demonstrate clinical success.

Authors state that long term follow-up in all patients who receive the implants is mandatory and findings will be published.</td>
</tr>
</table>

Validity and generalisability of the studies

- There are few data available concerning the use of two level (Bi-level) prostheses.

- Little long term data available particularly in relation to potential reduction in adjacent level degeneration as compared to fusion.

Specialist advisors' opinions

Specialist advice was sought from consultants who have been nominated or ratified by their Specialist Society or Royal College.

- Theoretical adverse events associated with this procedure included nerve root compression with device migration and airway or oesophageal obstruction with anterior displacement. The implant may cause excessive wear to articular surfaces, and device failure may cause spinal cord damage.

- There are anecdotal reports of heterotopic ossification and limited movement following this procedure.

- Many of the adverse events relating to surgical decompression with this procedure are equally relevant to cervical fusion

- 10 year comparative data compared to cervical fusion may be necessary before efficacy is demonstrated.

- A small number of spinal units undertake this procedure.

- No particular training requirement is necessary for operators with experience in anterior cervical disc surgery

Issues for consideration by IPAC

- IPAC has already produced guidance on artificial discs for the lumbar spine. IPG 100 http://www.nice.org.uk/ipcat.aspx?o=56892

- Variability of efficacy and safety between devices particularly tendency to create MRI artefact.

- Controversy regarding the role of prostheses for patients with neck pain but no nerve root or spinal cord compression

References

(1) Sekhon LH. Cervical arthroplasty in the management of spondylotic myelopathy. Journal of Spinal Disorders & Techniques 2003; 16(4):307-313.

(2) Sasso RC. Bryan cervical disc replacement: single-surgeon experience from U.S. IDE. Company abstract . 2004.

(3) Goffin J, Van Calenbergh F, Van Loon J, Casey A, Kehr P, Liebig K et al. Intermediate Follow-up after Treatment of Degenerative Disc Disease with the Bryan Cervical Disc Prosthesis: Single-Level and Bi-Level. Spine 2003; Vol. 28(24):15.

(4) Wigfield CC, Gill SS, Nelson RJ, Metcalf NH, Robertson JT. The new Frenchay artificial cervical joint: Results from a two-year pilot study. Spine 2002; Vol. 27(22):15.

(5) Porchet F, Metcalf NH. Clinical outcomes with the Prestige II cervical disc: preliminary results from a prospective randomized clinical trial. Neurosurg Focus 2004; 17(3):E6.

Appendix A: Additional papers on prosthetic intervertebral cervical disc replacement not included in the summary tables

Article title	Number of patients/follow-up	Comments	Direction of conclusions
Bryan, V. E., Jr. 2002, "Cervical motion segment replacement", *European Spine Journal*, vol. 11 Suppl 2, p. S92-S97.	n=97 Follow up to 2 years	Longer follow up reported in tabled studies	Efficacy comparable to fusion for pain relief and QOL scores. 5-10 year outcomes required to demonstrate advantage in reducing degenerative disc disease in adjacent segments
Goffin, J., Casey, A., Kehr, P., Liebig, K., Lind, B., Logroscino, C., Pointillart, V., Van Calenbergh, F., Van Loon, J., Cooper, P. R., Benzel, E. C., Haid Jr, R. W., Sonntag, V. K. H., McCormick, P. C., & Traynelis, V. C. 2002, "Preliminary clinical experience with the bryan cervical disc prosthesis", *Neurosurgery*, vol. Vol. 51, no. 3, p. 01.	n=60 Follow up 1 year	Longer follow up reported in tabled studies Same patients as Goffin 2003	90% clinical success at 1 year (30 patients) No measurable migration of devices.

Appendix B: Literature search for prosthetic intervertebral cervical disc replacement

The following search strategy was used to identify papers in Medline. A similar strategy was used to identify papers in EMBASE, Current Contents, PreMedline and all EMB databases.

For all other databases a simple search strategy using the key words in the title was employed.

1 disc replacement.tw. (49)
2 1 and cervical.tw. (3)
3 *Intervertebral Disk Displacement/su (809)
4 Cervical Vertebrae/su (1519)
5 3 and 4 (98)
6 5 and prosthe$.tw. (3)
7 2 or 6 (6)
8 from 7 keep 1-6 (6)