ELSEVIER

Seminars in
SPINE
SURGERY

Disc Replacement: Postoperative Imaging

Lali H.S. Sekhon, MD, PhD, FRACS,* and Paul A. Anderson, MD†

Cervical arthroplasty is being increasingly used for the management of degenerative spinal disease. As more experience is obtained with the devices currently available, the need for postoperative imaging has heightened. Plain X-rays are still useful for the assessment of device positioning and range of motion and to rule out potential device migration. CT scanning can be combined with this but incorporation of newer devices into bony endplates is difficult to visualize. In cases where neural structures need to be assessed at operated or adjacent levels MR scanning is suitable in most titanium-based devices but produces significant artifact in cobalt-chromium alloy-based devices. In this latter group CT myelography, more invasive than MR scanning, will need to be utilized. As our experience with the devices and their imaging increases, these recommendations may change but material properties play a greater role in the decision-making of type of modality used for postoperative imaging in scenarios where interbody fusion is performed.
Semin Spine Surg 18:99-108 © 2006 Elsevier Inc. All rights reserved.

KEYWORDS arthroplasty, MRI scan, artifact, fusion, artificial disc

Placement of an artificial disc prosthesis, after performing an anterior cervical decompression, is an emerging technology that is changing the approach to cervical spine pathology.[1-4] In contrast to previous fusion techniques, arthroplasty aims to preserve cervical motion, thus preventing complications associated with rigid arthrodesis and subsequent segmental loss of motion. Several prostheses, now available for clinical use, use different materials and design in their manufacture. Clinical series reporting early results with these implants are appearing.[1,5-8] Reports of shortcomings as well as successes are also being described.[9] With at least five cervical arthroplasty devices and a similar number of lumbar prostheses, refinement of indications and an understanding of the importance (or lack there of) of current design features is the next short- to medium-term goal. Ultimately only long-term follow-up will show whether the shortcomings of fusion surgery have been adequately addressed or whether new, previously unrecognized, problems will occur with this preservation of motion.

History and Rationale

Historically, anterior approaches in the cervical spine have included anterior cervical discectomy alone (ACD), anterior cervical discectomy with fusion (ACDF), and ACDF with anterior plating.[10] Failure of fusion resulting in pseudoarthrosis is reported to occur in up to 20% of cases.[11] Successful fusion may avoid these potential downsides, but the fusion of two vertebral bodies eliminates a spinal motion segment and mounting evidence suggests this may be detrimental, with biomechanical studies reporting increased stress/strain at levels adjacent to a fused segment.[12,13] In clinical studies, adjacent segment degeneration has been demonstrated in 2.9% of patients with fusion, giving an actuarial 10-year risk of 25.6%,[14] with the implication that at least one in four patients who undergo a successful cervical fusion will need further surgery, for accelerated adjacent segment disease, some time in the future. It has been argued that this relatively high figure of further surgery may actually reflect the likely outcome of accelerated disc degeneration in this subtype of patient, predisposed to disc degeneration, that they would have developed adjacent degeneration with or without fusion surgery. This has been supported by the work of Goffin and coworkers.[15] They found a similar rate of degenerative progression in both groups, suggesting that adjacent segment disease cannot solely be attributed to the natural history of degenerative disease. More recently, however, Robertson and coworkers have suggested from a randomized review of fusion versus arthroplasty, that at 2 years, the incidence of adjacent segment degeneration after fusion is already much higher.[16]

*SpineNevada, Reno, NV, USA.
†Department of Orthopedic Surgery and Rehabilitation, University of Wisconsin, Madison, WI, USA.
Financial Disclosure: L.H.S.S. is a consultant for Stryker Spine, and P.A.A. is a consultant for Medtronic Sofamor Danek and Stryker Spine.
Address reprint requests to Dr. Lali Sekhon, SpineNevada, 75 Pringle Way, Reno, NV 89502 USA. E-mail: sekhon@spinenevada.com.

1040-7383/06/$-see front matter © 2006 Elsevier Inc. All rights reserved.
doi:10.1053/j.semss.2006.03.011

Table 1 Cervical Disc Prostheses in FDA Investigations 2005

	Material	Bearing Surface	Number of Articulations	FDA Status	Center of Rotation	Fixation	Bone Ingrowth	Suitable Postoperative Imaging Modalities
Bryan	Titanium alloy Polyurethane	Metal on polymer	2	Completed enrollment	Mobile	Mortice	Titanium beads	X-ray CT MR
Prestige ST	Stainless steel	Metal on metal	1	Completed enrollment	Mobile	Screws	Titanium beads	X-ray CT Myelogram
Prestige LP	Titanium carbide	Metal on metal	1	Completed enrollment	Mobile	Fins	Titanium beads	X-ray CT MR
PCM	CoCrMo Polyethylene	Metal on polymer	1	In FDA trial	Fixed	Surface ridges	Titanium Plasma spray CaP	X-ray CT Myelogram
Prodisc C	CoCrMo Polyethylene	Metal on polymer	1	Completed enrollment	Fixed	Fixation	Titanium Plasma spray CaP	X-ray CT Myelogram
Cervicore	CoCrMo	Metal on metal	1	In FDA trial	Mobile	Fins	Titanium Plasma spray	X-ray CT Myelogram
Kineflex C	CoCrMo	Metal on metal	1	In FDA trial	Fixed	Keel	Titanium Plasma spray	X-ray CT Myelogram

Cervical disc replacement preserves motion after decompression with the aim of preventing adjacent segment stress. It also avoids the morbidity associated with cervical immobilization and autologous bone graft harvesting and eliminates the potential infective risks associated with allograft bone.[17] Intervertebral disc arthroplasty is a concept that was first described in the 1960s, when Fernstrom placed stainless steel intercorporal endoprostheses between adjacent vertebra.[18] The majority of prostheses were placed in the lumbar spine but 13 cervical arthroplasties in eight patients were reported. Reitz and Joubert subsequently reported on their experience with 75 cervical prostheses in 32 patients.[19] No further reports of this prosthesis were published and the placement of these devices was abandoned after problems with device subsidence and segmental hypermobility. Subsequently, the development of new cervical prostheses has been slower than that seen in the lumbar spine. The rapidly expanding modern experience with cervical disc arthroplasty was initiated with the reported implantation of an artificial cervical joint in 20 patients.[20] Known as the Cummins–Bristol joint, it was a two-piece, stainless steel, metal-on-metal, ball-in-socket construct secured to the anterior vertebral body by screws. This device was manufactured in one uniform size, unable to be adapted to individual anatomy, and had a bulky profile. At follow-up, 16 of 18 patients demonstrated radiographic evidence of preserved intervertebral motion. Excessive disc space distraction to accommodate the prosthesis with consequent facet joint separation was proposed as the cause of failure. Symptomatic improvement was reported in 16 of 20 patients. Several incidents of screw breakage and pullout led to the number, placement, and design of the screws being varied. Despite these problems, this pioneering study demonstrated the feasibility of cervical arthroplasty.

Design Principles and Prostheses Available

Cervical arthroplasty prostheses aim to maintain the normal range and type of intervertebral motion while transmitting axial loading forces from the vertebral body above to the one below. The design of modern intervertebral disc replacements can therefore be classified in terms of how the prosthesis allows motion and how it relates to the adjacent vertebral body. These two broad traits are further broken down into the issues of articulation and kinematics, design and fixation, and materials.[21] The key features of the commonly available devices are summarized in Table 1.

Articulation and Kinematics

Normal motion between two vertebral bodies occurs around a point described as the "instantaneous center of rotation." While the location of this point varies between levels, it is generally situated in the posterior half of the upper portion of the inferior vertebral body. Interbody motion is not a pure rotation and involves a degree of translation. The location of the center of rotation of a prosthesis should attempt to mimic the natural situation. The constraint of the prosthesis is the degree to which it allows movement other than uniaxial rotation.[22] A device can be constrained, semiconstrained, or