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Cervical spondylosis. Part III: Cervical arthroplasty

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Summary An appreciation of the frequency with which cervical fusion accelerates adjacent disc disease has led to the development of mobile artificial disc prostheses. At least six models are well advanced in clinical trials. Initial results show that such discs are as effective as current surgical techniques involving fusion, that they have few complications and that they preserve the range of movement of the relevant intervertebral joint. The question as to whether they will endure and prevent accelerated disc disease will only be answered by very long-term studies (10–20 years). Meanwhile, the results are encouraging and cervical arthroplasty may well be indicated in the majority of cervical disc problems requiring surgery, provided they are not associated with other local spinal disease or instability.

Introduction

In 2002, at the end of a previous paper in this series,[1] I predicted that there would be slow progress towards non-fusion, arthroplasty techniques in the management of cervical disc disease and accompanying spondylosis. I was very enthusiastic at that time but did not for a moment imagine the explosion of interest in implantable, mobile, cervical disc joints that is occurring currently. This may be premature but there is no evidence that it is misdirected or dangerous. An enormous clinical effort and commercial investment is driving it forward. Several recent meetings have been devoted to the subject and at least two dedicated journal supplements have been published in 2004.[2,3] Cervical arthroplasty appears to have arrived, no disasters have blunted enthusiasm as yet, and the subject deserves serious appraisal.

Historical evolution of anterior discectomy

Anterior cervical discectomy and fusion was first described in 1958[4,5] and has since become one of the most effective and reliable of spinal surgical procedures. The early operations used iliac crest autograft to replace the removed disc and encourage fusion, but an unacceptable rate of graft collapse and protrusion led to the first modifications. Some surgeons employed plating for support; others performed only simple discectomy without

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grafting and with vertebral end plate preservation. The latter has proved reliable but the consequent disc space narrowing may entrap nerve roots in the foramina and also fusion is less certain. Some patients with failed fusion complain of increased local neck pain. However, it was also observed that complete success was possible in the absence of fusion.

Disc space narrowing and graft donor site complications (pain and infection) resulted in the increased use of allograft. This was later rejected because of frequent graft failure and the risk of disease transmission. The next development was of metal spacers and cages, supplemented by artificial bone substitute and bone morphogenetic protein (BMP). Metal has a tendency to fracture the vertebral end plate and this has led to the development of plastic synthetics, such as polyetheretherketone (PEEK), which have a hardness similar to bone. By combining PEEK and BMP with the use of a cervical plate, a 100% fusion rate has been reported,[6] but this requires multiple (and expensive) implants.

A high fusion rate and long follow-up has led to an appreciation of the significant complications of fusion. Accelerated degenerative disease adjacent to congenital cervical fusion is well known. Iatrogenic fusion produces the same effect. Long-term follow-up has shown 50–92% of patients undergoing fusion may develop radiographically confirmed adjacent level degeneration.[7,8] Twenty-five percent of operated cases will develop radiculopathy or myelopathy due to such degeneration[9] and 16–19% will require a further operation.[7,10] These observations have led a significant number of spinal surgeons to believe that the future of cervical disc surgery lies with arthroplastic techniques that maintain the mobility of the disc joint.

In addition to 'knock on' discopathy, as described above, multiple fusions lead to restricted neck movement that can be socially disabling and even potentially dangerous, as when it precludes emergency endotracheal intubation.

The development of cervical arthroplasty

One pioneering attempt to replace cervical discs occurred in the 1960s when Fernstrom[11] inserted a spherical metal device into the intervertebral space, but this failed very frequently because it either fractured the end plate or caused hypermobility. Though developments occurred in lumbar arthroplasty in the 1980s, the next significant progress in the cervical area was at Frenchay Hospital, Bristol in the early 1990s. Brian Cummins* and his colleagues devised a metal on metal, ball and socket joint secured by screws.[12] A number of practical problems stimulated design revision and eventually the system was acquired and further developed by Medtronic as the Prestige range of prostheses (Fig. 1).

Using the first modified Prestige prosthesis, a prospective trial was started in 2000. The preliminary results in 15 patients showed 100% success in preserving movement.[13] Minor technical problems (screw breakage) had no clinical repercussions. At much the same time, clinical trials of other metallic designs began. These include the Bryan disc (Medtronic), the PCM disc (Cervitech), the ProDisc-C (Synthes) and the CerviCore disc (SpineCore).

The Bryan disc consists of a saline-lubricated polyurethane core between two titanium plates which adhere to the vertebra by bony ingrowth into the porous titanium surface thus avoiding screws and allowing a very low projection profile (Fig. 2). It also has some shock absorbing potential. Over 2000 such discs have been implanted, mainly in Europe and Australia, but few have been prospectively evaluated. A series of 26 patients with one or two level implants reported from Canada has shown preservation of movement in all patients evaluated radiologically,[14] with a mean range of segmental movement (ROM) of 7.8° which was not significantly different from the preoperative ROM of 10.1°. The overall spinal mobility (C2–C7) increased by 10.5°, presumably because pain was reduced.

The PCM disc (Fig. 3) combines TiCaP-coated cobalt–chromium with ultra-high molecular weight polyethylene, a familiar, tried and tested combination. Trials are less well advanced but again the first anecdotal reports are of successful movement preservation.[15] The ProDisc-C (Fig. 4) copies a design used successfully in the lumbar region. It consists of two cobalt–chromium–molybdenum endplates with a polyethylene insert. Immediate stability is provided by a central keel, which slides into a prepared groove in the vertebral body. The CerviCore disc is a metal on metal design very similar to Prestige.

A recent and very interesting development has been the production of a non-metallic disc (Neodisc) by a British company, Pearsall's. This consists of a woven (embroidered) polyester 'ligament' enclosing an artificial disc nucleus made of medical grade silicone (Fig. 5). Independent analysis of explanted discs in animal studies has shown biointegration of

*This paper is dedicated, posthumously, to Brian Cummins whose enthusiasm for life and neurosurgery will never be forgotten by his friends.