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Review

The Research of Artificial Cervical Disc Replacement

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Abstract

Cervical arthroplasty after anterior decompression with insertion of a prosthetic total disc replacement has been suggested as an alternate to anterior cervical fusion. It develops quickly during recent years. Currently there are several cervical arthroplasty devices. Each device varies in terms of materials, range of motion and constraint. Early studies suggest that in the short term, the complication rate and efficacy is no worse than fusion surgery. Long-term results have not yet been reported. This review examines the current prostheses as well as discussing issues regarding indications and technique. It is hoped that an improvement of cervical arthroplasty occurs in terms of materials and design as spinal surgeons enter a new times of the management of cervical spine disease.

Key words: Arthroplasty; cervical prosthesis; fusion; surgery

INTRODUCTION

With the development of society and changes in life style, the incidence of spondylosis is increasing. Conservative treatment is sometimes without effect and patients need surgery. So far anterior cervical discectomy and fusion(ACDF) is the prevailing surgical procedure to treat symptoms caused by cervical degenerative disc disease(DDD). However, the accelerating degeneration to adjacent disc levels, which is a consequence of increasing stress due to the interbody fusion of the cervical spine, requires considerable attention by surgeons. Therefore the artificial disc prosthesis was created. Since China adopted these new techniques from 2003 to the present more than 1000 people have received this kind of surgery[1].

The history of cervical prosthesis

The first report of cervical prosthesis was published by Reitz and Fernstrom in a South Africa medical magazine in 1964 when they placed a stainless steel intercorporal endoprosthesis between adjacent vertebrae. No further reports of this prosthesis were published in the next few years. The next cervical prosthesis was the Bristol Disc. It is a two-piece, stainless steel, metal-on-metal, ball-in-socket construct secured to the anterior vertebral body by screws. This device is produced in a uniform size, and could not be adapted to an individual's anatomy[2]. Although the prosthesis failed, these pioneering studies demonstrated the possibility of cervical arthroplasty.

The design and materials

Nowadays there are several kinds of cervical prosthesis. The designs of the arthosis are mainly of two types: one is a ball-in-socket design that imitates the joints of extremities; the other is an annular fibrosus and nucleus design that imitates the normal human intervertebral spaces. Stability of the device is divided into an initial stability that relies on some forms of constraining mechanism, and long-term stability that typically implies osteointegration of the device into surrounding bone. Short and long-term fixation is used with the aim of preventing subluxation, subsidence, displacement or dislocation. The materials used to manufacture the device should be of reliable biocompatibility. Metal components have been produced from

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titanium, stainless steel or chromium, and are commonly used in alloys to decrease corrosion. Coating of the vertebral interface surface to encourage bone in-growth makes use of several materials including calcium phosphate, hydroxyapatite and porous titanium[3,4].

The available cervical prosthesis and clinical results

Today, the Bryan(Medtronic Sofamor Danek, USA) cervical disc prosthesis is the most widely used cervical prosthesis in clinics. It consists of a polyurethane nucleus designed to fit between two titanium alloy surfaces. A polyurethane sheath surrounds the nucleus and is attached to the titanium alloy surfaces with titanium wire, forming a closed compartment that may contain any wear debris and prevent soft tissue in-growth. Long-term stability is provided by bone growth into the porous-coated titanium alloy end plates[5,6]. In 2002 Goffin reported on 60 patients with single-level cervical spondylosis. Ninety-three percent of them were symptomatic cervical radiculopathy and underwent implantion with the Bryan prosthesis after a standard anterior cervical discectomy. The 1 year follow-up showed a clinical success of 86% to 90%. There was no measurable subsidence of the devices. Migration of the devices was only detected in one patient. No devices had to be explanted or surgically revised[7]. Sasso and colleagues reported in 2007 that they followed 115 patients who were randomized in a 1:1 ratio to a Bryan artificial disc replacement or an anterior cervical fusion. Of these patients, 99 cases were followed for 2 years. They collected data at 6 weeks, 3, 6, 12, and 24 months after surgery, including the Neck Disability Index(NDI), the Visual Analog Scale(VAS) of neck and the arm pain, SF-36 outcome measures, and range of motion (ROM) assessment, and found there were significant differences between the two groups. The Bryan artificial disc replacement compared favorably to anterior cervical discectomy and fusion for the treatment of patients with 1-level cervical disc disease[8,9]. Here in China, Yang Shuhua and colleagues reported in 2008 that they finished 23 cervical artificial disc replacements on 19 patients and followed them up for average 29 months. No neurological or vascular complication was found during or after surgery. JOA scores increased from an average of 8.6 to 15.8. There was no prosthesis subsidence or excursion. Replaced segments achieved stability and restored partial or normal ROM, and there was no obvious loss of lordosis. CT or MRI follow-up showed excursion(< 1.5 mm) in 2/23 levels and no ossification in the replaced levels. Patients recovered quickly and radiographic evidence supports the procedure as being safe[10].

ProDisc-C(Spine Solution, Paoli, USA) were first used in humans in December 2002[11]. It is constructed of two cobalt-chrome metal end plates and a fixed polyethylene core that provides coupled motion without independent translation when the device is implanted. The ProDisc-C maintains a single centre of rotation in the vertebral bone below the intervertebral space. Implantation takes place by inserting a keel in a slot of the cranial and caudal vertebral body. The surfaces of the prosthesis towards the bones bear a plasma-spray titanium layer for secondary fixation[1,12]. Nabhan and colleagues compared the outcomes of cervical disc replacement using ProDisc-C and the tradition anterior cervical discectomy and fusion. At 3, 6, 12, 24, and 52 weeks after surgery, cervical spine segmental motion decreased over time in the presence of disc prosthesis or fusion device. However, the loss of segmental motion was significantly higher in the fusion group. There was significant neck and arm pain reduction after surgery, with no significant difference between the two groups[13,14]. There is still no report about this prosthesis being used in Chinese hospitals.

PCM(Cervitech, Roundhill, USA) is a polyethylene-on-metal device which includes a uniarticular design with one center of rotation maintained below the intervertebral space. The end plates are manufactured from cobalt-chrome alloy, and the outside of the components feature a TiCaP coating. Primary stability is assured by a press-fit implantation[12,15]. It was first used in humans in December 2002 in Brazil[5], Luiz Pimenta et al reported a prospective study in 2007 in which a total of 229 PCM implantations were concurrently enrolled between single-level versus multilevel cervical arthroplasty. Following anterior cervical neurologic decompression 71 patients required porous single cervical arthroplasties while 69 patients underwent 158 multilevel PCM cervical arthroplasties. Comparing the NDI and VAS scores after surgery, this prospective study showed significantly improved clinical outcomes for multilevel cervical arthroplasty compared with single-level cervical disc replacement[15,16]. PCM has already received U.S. Food and Drug Administration(FDA) approval.

Indications and contraindications

In order to get favorable outcomes with disc replacement surgery, it is very important to master the indications. The FDA suggests that when stabilizing the cervical spine, one-level cervical spondylosis with cervical radiculopathy or myelopathy are suitable cases. Some researchers have reported satisfactory outcomes with mutil-level disc replacements[17]. At present the following are considered indications:① Spondylosis

with cervical radiculopathy or myelopathy causing neurological symptoms or signs; ② Absence of serious degeneration of adjacent disc levels; ③ Restriction of surgery levels to C3-4 to C6-7; ④ Ensure that the degeneration levels are no more than two segments; ⑤Ensure that there is no evidence of instability of the cervical spine through X-ray or CT; ⑥ Exclude patients with osteoporosis or other metabolic disease. Ossification of posterior longitudinal ligament, ankylosing spondylitis and rheumatoid arthritis are also contraindications[17,18].

Face problems and prospect

As a new technology there are still many problems facing artificial cervical disc replacement. The sinking of the prosthesis and heterotopic ossification are serious problems. Revision of cervical artificial disc replacement has been reported[19]. We firmly believe that with the continued development of technology and design, these problems will eventually be resolved. At present, artificial disc replacement surgery still can not shake the position of fusion, but as a complement, it enlarges the orthopedics surgeon's choices, and provides expanded options to the area of cervical vertebra surgery[20].

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