Editorial

Non-fusion surgeries of the cervical spine

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Anterior spinal fusion is one of the most commonly performed procedures of the cervical spine for traumatic, degenerative, or malignant conditions that require excision of intervertebral discs or vertebral bodies. Autogenous bone grafting has been shown to have a 95% or greater fusion rate for single-level surgery. The introduction of artificial spacers or bone substitutes has reduced the problem of donor-site pain, and anterior cervical plating has claimed further enhancement of fusion rate and obviated the need for postoperative external immobilisation. Despite these satisfactory outcomes, spinal fusion, at least theoretically, adds extra stress to the adjacent segments and may accelerate degeneration. On the other hand, it has also been argued that adjacent segment degeneration is merely part of the natural history of the disease in genetically predisposed individuals. Nevertheless, preservation of motion of the functional spinal unit after disc excision or non-fusion surgeries remains a reasonable goal.

The idea of replacing the intervertebral disc is not new. In the past 50 years, over 100 designs ranging from a simple metallic ball to complex composite polymers with different metal backings have been reported. Most are used for the lower lumbar spine, which is the most common site of degenerative disc disease as a cause of low back pain. With better understanding of the biomechanics and kinematics of the functional spinal unit, modern designs are more sophisticated and better resemble the natural mechanics. Although the short-term results appear satisfactory, medium- and long-term results are not yet available. It is ironic that the best clinical outcome actually occurred in segments that went into spontaneous fusion, making the artificial disc a very expensive intervertebral spacer for fusion. Some prospective randomised controlled trials claimed superior results from artificial disc replacements, but the control group consisted of stand-alone intervertebral cages that are notorious for producing the worst results. Conditions in the cervical spine are inherently less hostile than in the lumbar region. The size of the disc, the loading forces involved, the facet joint anatomy, and the kinematics are all very different from the lumbar segments, which should render disc replacement theoretically more successful. Indeed, in recent years the number of reports in the literature on the cervical spine is catching up with that of the lumbar spine. In general, around 5º to 7º of segmental motion can be preserved but whether this is the reason for the paucity of observed adjacent segment degeneration remains unknown, as most of the follow-ups were very short. That artificial discs are being implanted into younger and younger patients who have 30 or 40 years of life expectancy ahead is therefore a matter of concern.

The history of the development of joint replacement for the hips and knees may provide insight into the future of artificial disc replacement. The closer the anatomy and kinematics of the joint are reproduced, the more likely it will succeed. Fixation of the implant to the recipient bed has evolved through different generations of cement pressurisation, surface in-growth, anatomic press-fitting with and without screw augmentation, etc. However, long-term success is limited by wear debris osteolysis, mechanical loosening, and implant migration. Revision surgeries
are becoming as common if not more prevalent than primary implantations. Reconstructing major bone defects is challenging and risks complications. Imagine if this happens in the cervical spine after an artificial disc replacement, would patients be prepared to undergo multiple revision surgeries when needed? Are the surgeons capable of salvaging these situations, restoring bone stock, or have the bridges been burnt? Remember the bottom line, namely, that one cannot afford to put the spinal cord at risk.

Our group at the University of Hong Kong has approached this problem from a different angle and been interested in the feasibility of biological regeneration or replacement of the disc with motion preservation. We believe that the best-designed disc is what nature has given us. Borrowing the concept of successful large organ transplants, we started a series of experiments on intervertebral disc autografting, allografting, and fresh frozen allografting in primates. We found that the transplanted disc could achieve the objectives of being mechanically stable and preserving a mobile segment without risking neural tissues. However the transplanted disc height does decrease in the first few months suggestive of degeneration. Since 2000, we have performed a pilot study in humans in Beijing. The results have been extremely encouraging. We have carefully followed up the first series of 5 patients for a minimum of 5 years. Healing of the bony endplates is almost guaranteed, with no evidence of immunoreaction. In addition to what we expected from the animal studies, we have identified 2 other phenomena. First, malpositioned allografts were able to remodel to a completely normal position with time. This would not have been feasible in the case of artificial disc replacements, whereby a malpositioned implant is destined to fail. We are currently conducting studies to understand whether the kinematics are consequentially restored with the anatomic remodelling. Second, at the 5-year follow-up, at least 40% of the transplanted discs showed a bright T2 signal in the nucleus pulposus indicating the presence of metabolism and hydration. Clinically the motions available from the transplant were comparable to those of artificial disc replacement and none resulted in spontaneous fusion. Herniation of the transplanted disc, segmental instability, or adjacent segment degeneration were not seen. Neither was osteolysis nor implant migration. Although we have yet to undergo a revision surgery, we envisage that if the need arises it can easily be revised to another allograft transplantation, artificial disc replacement, or the time-honoured spinal fusion. Sourcing of allografts, screening for transmittable diseases, and preservation technology are all issues to be addressed.

In order to biologically repair or regenerate the disc, we need to better understand the basic mechanism of disc degeneration at the molecular level. Therefore, our group at the University of Hong Kong has established a comprehensive research programme to study the epidemiology, genetics, functional genomics, proteomics, and nutrition, and how these affect the nano-structure and mechanics of the disc. We believe that biologic repair and/or disc replacement has a definite role as a non-fusion strategy in the management of degenerative disc disease. Until then, artificial disc replacement will still be around for some time.

REFERENCES