

Spinal Disc Replacement Surgery



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What is Disc Replacement Surgery?

Disc replacement surgery (arthroplasty) involves replacing a herniated intervertebral disc with a prosthesis designed to retain the mobility of the spine.

The goal of disc replacement is to reduce pain and neurological symptoms associated with nerve root or cord compression. The disc prosthesis is designed to re-establish the original disc height and emulate the natural biomechanics and movement of the spine. Disc replacement is an option for certain patients when non-surgical measures have failed to resolve or reduce symptoms. It is an alternative to the traditional anterior discectomy, decompression and fusion techniques.

Currently both cervical and lumbar disc replacement technologies are available for use in Australia. The Medicare Benefits Schedule has approved lumbar disc arthroplasty since 2006. Certain cervical disc prostheses are Therapeutic Goods Association listed or registered in Australia. However, cervical prostheses do not attract Medicare funding. Individual Workcover claims may cover the cost of cervical disc replacement according to patient circumstances.

Discogenic Pain

Back and neck pain are common conditions managed in general practice. An estimated 1.9 million Australians have lower back pain. The BEACH¹ study found that back syndromes with radiating pain account for 1.0 per 100 patient encounters, and neck syndromes account for 0.4 per 100 patient encounters. Referrals to a specialist for back pain occur in 4.7 per 100 patient encounters of this type. The prevalence of cervical or lumbar disc herniation is difficult to determine. While a minority of patients with cervical or lumbar disc herniation require surgery, the overall prevalence of back and neck

pathology is expected to increase as the Australian population ages.

Spinal pain may arise from numerous sources, including the intervertebral disc, facet joints, ligaments, muscles and/or nerve roots. The patient must be thoroughly assessed to determine which of these structures are the major contributors to pain and other symptoms. Neurological symptoms from disc herniation (see Figure 1) are the result of mechanical compression of nerve roots or the spinal cord. Also contributing is the buildup of inflammatory mediators in the disc space and surrounding areas.

Although incompletely understood, the basic concepts of disc degeneration, herniation and nerve root or cord compression are well categorized. Once the axial skeleton reaches maturity at about 20 years of age, hydrophilic chondroitin proteoglycans are gradually replaced by less hydrophilic keratin proteoglycans. Genetics and modifiable risk factors such as smoking contribute to disc dehydration. Dehydration and compression over time causes a loss of disc height.

Dehydration may encourage the formation of cracks in the annulus fibrosus, through which disc material can herniate and compress spinal nerves or the spinal cord itself. This loss of disc height can also cause buckling of the ligamentum flavum into the spinal canal. Arthritic changes such as vertebral end-plate sclerosis contribute to disc degeneration as nutrients and metabolites are less able to transfer from the disc to the bloodstream. This can lead to pain.

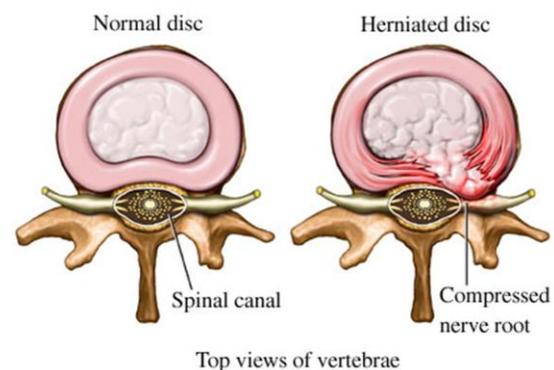


Figure 1.

History and Philosophy of Disc Replacement

The first disc replacement surgery was performed by Fernström in the 1950's with minimal success. His technique involved using iron spheres in the disc

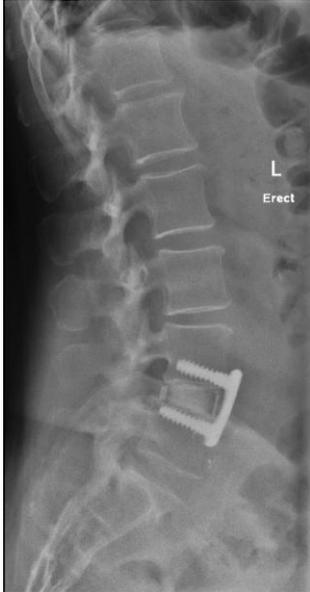


Figure 2- Anterior Lumbar Interbody Fusion

space to preserve height and motion. From 1970's new patents for cervical and lumbar disc prostheses were been regularly approved, however few of these gained clinical use. Since the 1990's, spinal disc replacement technology has been steadily improving.

Discectomy and fusion remains the gold standard of anterior surgical treatment for cervical and lumbar radiculopathy. The theory behind fusion

is to eliminate movement at the level of the spinal functional unit. This technique followed the accepted idea that movement in degenerated joints causes pain. The early treatments for hip and knee degeneration were also fusions (arthrodesis). Currently peripheral joint arthrodeses are infrequently performed as joint replacement technology has continued to improve.

Intervertebral disc replacement has developed in parallel to other joint replacement surgeries. However, intervertebral disc replacement has evolved more slowly due to the complex biomechanics of the spinal functional unit. It is only in the last 10-20 years that implant materials and surgical technique have converged to make intervertebral disc replacement a viable option.

Also driving this technological advancement is the theory that spinal arthrodesis causes increased load bearing and possible degeneration of the joint segments above and below the fused level. It is still a controversial topic. The opposing argument is that the adjacent spinal segments would have degenerated even without the added strain of fusion surgery. However, research² indicates that there is a 25.6% ten-year risk of developing adjacent segment disease after cervical discectomy and fusion. In the cervical spine re-operation rates for adjacent segment disease are reported at 2.9% per year.

Most patients report good outcomes of their spinal arthrodesis in terms of relief from pain and radicular

symptoms. While few, patients who need additional surgery to correct further degeneration in adjacent segments may represent a preventable problem. The philosophy of disc replacement is to avert future degeneration. Although there are some promising results, it is a new technology and long term results do not yet show advantage over arthrodesis. Currently disc replacement is considered equivocal technology to traditional anterior discectomy and fusion.

Traditional Surgical Techniques vs Disc Replacement

Lumbar Spine

Traditional lumbar arthrodesis for disc herniation is performed via an anterior approach, called Anterior Lumbar Interbody Fusion or ALIF (see figure 2). The immediate surgical benefit is from the discectomy or indirect decompression from height restoration. The interbody graft maintains the height of the intervertebral disc space and also across the vertebral endplates with insertion of a biologic agent such as autologous bone graft or bone substitute. Metal plates and screws may be used to further stabilise and facilitate the fusion process.

Disc replacement is performed anteriorly. The intervertebral disc is removed and the end plates shaved to accommodate the disc prosthesis. Many disc types have a 'keel' for which grooves are cut in the vertebral end plate (see figure 7). The space is measured with a trial implant, and the actual prosthetic disc of the correct size is fitted into place (see figure 3). Instead of a rigid segment, a motion preservation level has been created.

Trials of the various disc devices show cautiously positive results. Clinical trials compare the results of various fusion methods to disc replacement. Early prosthetic models such as the Charité by DePuy Spine (now seldom used) reported 90% patient

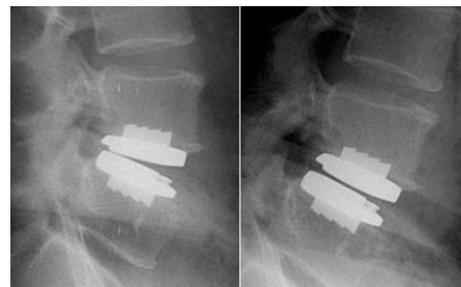


Figure 3 – ProDisc L (Synthes) in extension and flexion



Figure 4 – Anterior Cervical Discectomy and Fusion

satisfaction at ten years. Eight out of the 100 patients in the study later had a posterior fusion and three had surgery on adjacent levels. The more recent ProDisc L manufactured by Synthes was FDA approved in 2005 after a mean 8.7 year follow up reported 75%

good to excellent results. Another ProDisc study reported 6 prosthetic failures and one lumbar fusion out of 161 patients³.

In Australia the cost difference between lumbar fusion and disc replacement is not significantly different when implants, operating room and hospital stay are accounted for.

Cervical Spine

Anterior Cervical Discectomy and Fusion (ACDF) is the gold-standard treatment for cervical radicular and/or axial pain (see figure 4). The procedure is similar to the ALIF technique. Also similar is the procedure for insertion of a disc replacement (see figure 5).

There are as yet no long-term studies of cervical disc replacement. A 2 year clinical trial follow-up of 276 Prestige C prosthesis implantations compared to 265 fusions showed greater neurological success in the disc replacement group³. However, this and other trials have not demonstrated statistically significant differences between ACDF and disc replacement with clinical outcome scores. Long-term follow-up will elucidate the future success of cervical disc replacement, especially for adjacent segment disease rates.

Indications for Disc Replacement

Surgical treatment for spinal pain and radicular symptoms is an option when patients have failed non-operative treatment such as analgesia, membrane stabilizing drugs such as gabapentin, physiotherapy, corticosteroid injections and the passage of time. In general, surgical treatment is offered as an option after six to eight weeks of conservative treatment has failed to produce

significant benefit or if there are clear neurological deficits. Early surgery can prevent denervation of myotomes leading to permanent symptoms of numbness and weakness, and also the development of chronic pain syndromes.

Patients who may benefit from disc replacement surgery are generally younger (less than 60) and wish to retain their fitness and activity levels. Contraindications for disc replacement include active infection, osteoporosis, severe facet joint arthritis, allergy to the prosthetic materials and spinal metastases.



Figure 5 – ProDisc C (Synthes) in extension and flexion

Types of Disc Prostheses

Disc prostheses (figures 6 and 7) are designed to provide load bearing, height and motion to the intervertebral disc space. They can be classified as constrained, semi-constrained and non-constrained. This classification system describes the amount of motion allowed at the disc level. Each type of implant allows for a different range of flexion, extension, lateral bending, rotation and axial compression. A 'normal' spinal unit of disc and two facet joints is defined as semi-constrained; however no semi-constrained disc replacement has successfully reproduced all physiological movements. A constrained prosthesis has less mobility than the normal joint, while a non-constrained joint allows greater mobility. Just as a spinal arthrodesis affects adjacent levels by eliminating movement, so does the way a prosthetic disc allows movement can increase strain on the facet joints at that level and at adjacent

Figure 6. Cervical Disc Replacements

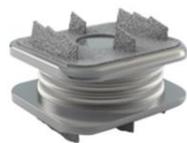
Prestige
(Medtronic)



ProDisc C
(Synthes)



M6 C
(Spinal-Kinetics)



levels. No prosthetic joint is as good as the healthy original, but it is anticipated that disc replacement will reduce the incidence of adjacent level disease.

Safety of Spinal Disc Replacement

Disc replacement surgery is a major operation and patients must be carefully

assessed and counseled before considering it as an option.

Complications specific to disc replacement include subsidence into the vertebra, migration, displacement and implant or vertebral end plate failure. These complications are reported to occur in less than five percent of patients. Complications related to the surgical approach include vascular or nerve injury and are also infrequently reported. General surgical risks such as pain and infection and the risks of general anaesthesia must also be considered on an individual patient basis.

presentation and/or publication is encouraged by the Surgical Association and Colleges. Patients should feel free to discuss their surgeons' experience and qualifications for spinal total disc replacement.

Summary

Disc replacement involves the insertion of motion preservation intervertebral disc prosthesis. The philosophy of this technique is hopeful reduction of adjacent segment disease. The technology has advanced exponentially. Current trials and research show promising longer term results, however fusion remains the gold standard. Watch this space!

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¹Britt H, Miller GC, Knox S, Charles J, Pan Y, Henderson J, Bayram C, Valenti L, Ng A, O'Halloran J 2005. General practice activity in Australia 2004–05. AIHW Cat. No. GEP 18. Canberra: Australian Institute of Health and Welfare

²AS Hilibrand et al. 1999. Radiculopathy and Myelopathy at Segments Adjacent to the Site of a Previous Anterior Cervical Arthrodesis. The Journal of Bone and Spine Surgery Vol. 81 No. 4 519-528.

³TJ Kishen, AD Diwan. 2010. Fusion vs Disk Replacement for Degenerative Conditions of the Lumbar and Cervical Spine: Quid Est Testimonium? Orthopaedic Clinics of N. America Vol. 41 167-181.

Figure 7. Lumbar Disc Replacements

M6 L
(Spinal-Kinetics)



ProDisc L
(Synthes)



Maverick
(Medtronic)



Surgeons must be extensively trained to insert the various models of disc prosthesis. Training programs are conducted by the various manufacturers of the disc prostheses. Peer review and collection of data for research and