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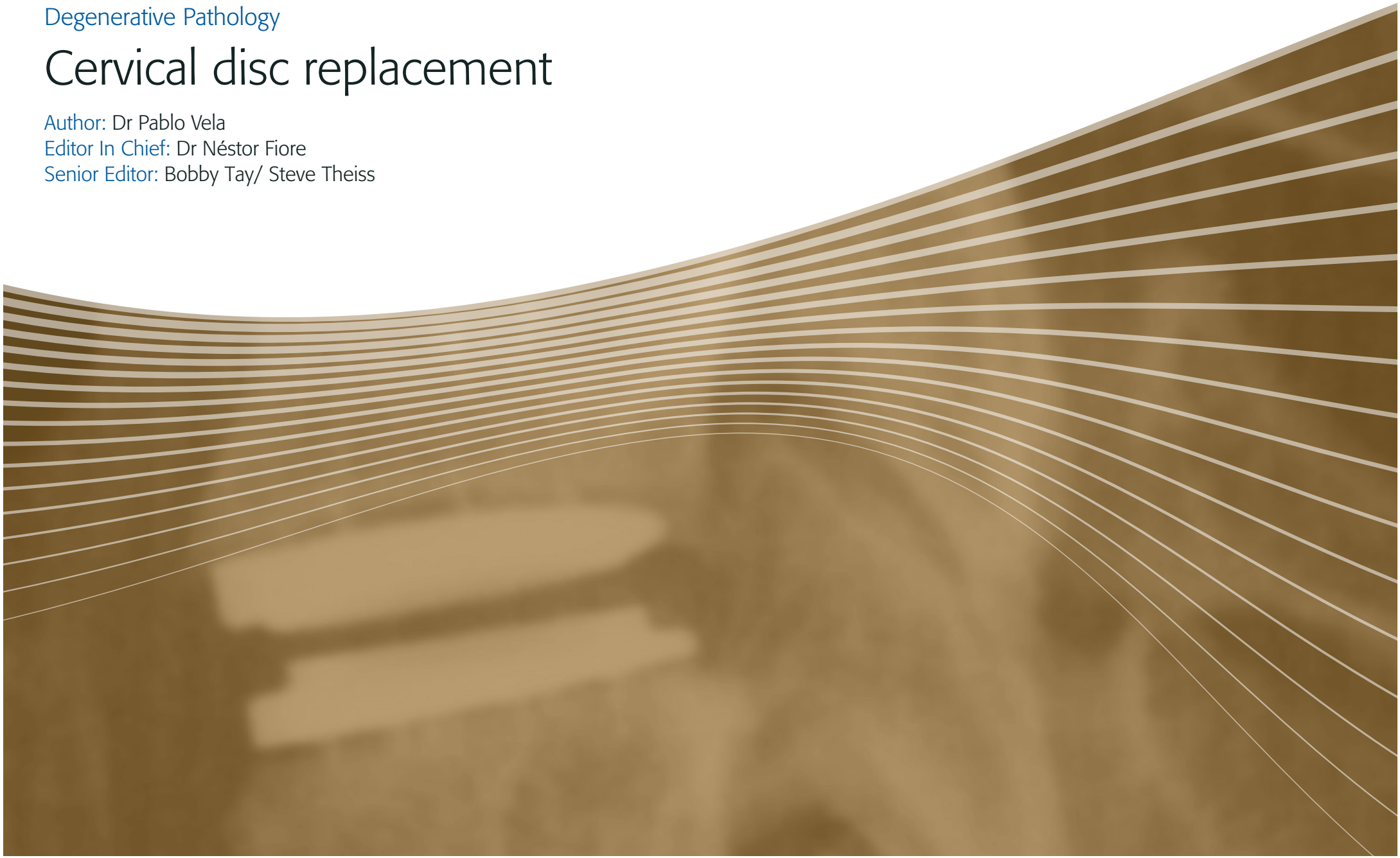
Degenerative Pathology

Cervical disc replacement

Author: Dr Pablo Vela
Editor In Chief: Dr Néstor Fiore
Senior Editor: Bobby Tay/ Steve Theiss



OBJECTIVES

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Degenerative Pathology

Cervical disc replacement

- To specify current indications.
- To explain details of the surgical technique.
- To identify possible complications and how to avoid them.
- To describe current outcomes.

CONTENTS

1. INTRODUCTION

Overview

One of the less controversial aspects of spine surgery is the treatment of degenerative pathologies in the cervical segment. Whether dealing with a radiculopathy, a myelopathy or a combined pathology, especially when there are less than 3 motion segments involved, there is wide consensus that an anterior approach with arthrodesis should be performed (when indicated).

> Cervical arthrodesis surgery has a long history with high success rates (approximately 90%), low rates of pseudoarthrosis and a high rate of patient and surgeon satisfaction (Pracyk and Traynelis, 2005).

However, sacrificing the movement of the treated segment has biomechanical disadvantages that can give rise to clinical problems, especially in regards long-term follow up (Hilibrand, Carlson, Palumbo, Jones and Bohlman, 1999). This is the reasoning behind the attempts since the 1960s to minimize the incidence of these problems by preserving the motion of the intervertebral disc.

The historical evolution of cervical arthroplasty has, in many ways, been similar to that of lumbar arthroplasty. The pioneer of this concept was Fernström. In the 1950s, Fernström reported the first cases of preservation of lumbar spine movement by placing steel spheres in the intervertebral lumbar space. In 1966, he reported the same technique in the cervical spine with spheres that were evidently smaller (Kim and Vaccaro, 2006). The clinical outcome was not good due to the development of hypermobility and the high rate of device subsidence. In similar fashion, the first modern lumbar prostheses, such as Charité™, were developed in the early 1980s and their cervical equivalents, such as Discover®, made their appearance two decades later.

Current investigation in clinical diagnosis, biomechanics and biomaterials has given rise to numerous models of cervical prosthesis with clinical outcomes generally similar to previous traditional arthrodesis but with the added advantage of preserved motion.

Many models of prostheses have been designed and many more are in the stage of development; however, only a few have undergone frequent use in a significant number of patients (Denaro, Papalia, Denaro, Di Martino and Maffulli, 2009; Hacker, 2006).

- Bryan® (Medtronic),
- Prestige® (Medtronic),
- Prodisc®-C (Synthes),
- Discover® (DePuy),
- PCM® (Cervitech).

2. BIOMECHANICS

The cervical contains the most mobile segments, capable of flexion-extension, lateral displacement, translation and rotation. It is also capable of spreading axial loads.

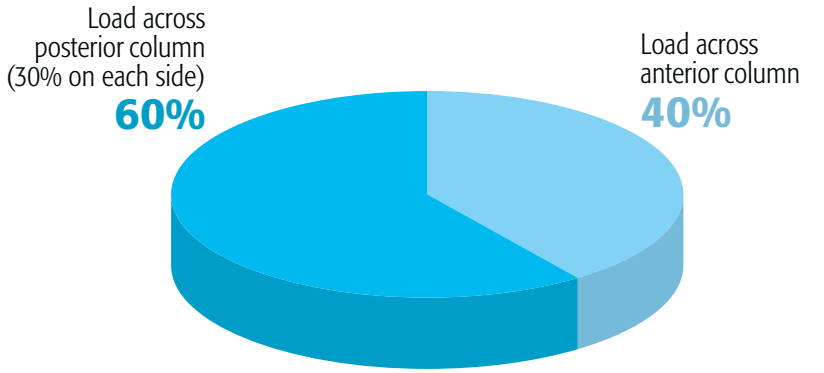
Cervical spine biomechanics rely on complex interactions between bone and ligament structures.

The stability of a cervical segment depends on several structures:

- the disc;
- facets and facet capsules;
- musculoligamentous structures.

To a large degree, the intervertebral disc is responsible for stability and plays a primary role in maintaining cervical spine lordosis.

Preserving cervical lordosis is critical for the proper function of the vertebral column and its contents.



Distribution of axial load transmission

However, when the disc fails, frequently due to degenerative changes, this homostasis is altered and sometimes the symptoms that appear do not respond to medical treatment and require surgery.

These goals can be achieved with an anterior arthrodesis; however, foregoing the movement of one or more segments alters the function of adjacent segments. This gave rise to the hypothesis of preserving segment movement in order to protect adjacent segments. Although it is impossible to detain or retard the development of adjacent segment disease due to the presence of other factors (especially genetic factors), it is likely that future research will demonstrate that this incidence phenomenon can be minimized with the use of disc prostheses.

Biomechanical principles of disc replacement

Although arthroplasty implants are essentially considered as surgical tools that preserve movement, they should also preserve spinal stability, resist axial loads and withstand torque and displacement forces. Therefore the design of any disc prostheses should efficiently imitate the functions of an intervertebral disc insofar as technology allows (Hacker, 2006; Pracyk and Traynelis, 2005).

This includes the following capacities:

- emulating disc movements;
- maintaining segment lordosis;
- mitating the disc's center of rotation (COR).

Although not static, in general terms the COR is located beneath the vertebral body, behind the midline on the sagittal plane. That is why the prosthesis must be placed properly during surgery, as explained in detail further along (Hacker, 2006).

The goal of any procedure is not only to decompress the structures that caused the symptoms, but also to maintain the stability and balance of the segment and of the entire cervical spine (Anakwenze, Auerbach, Milby, Lonner and Balderston, 2009).

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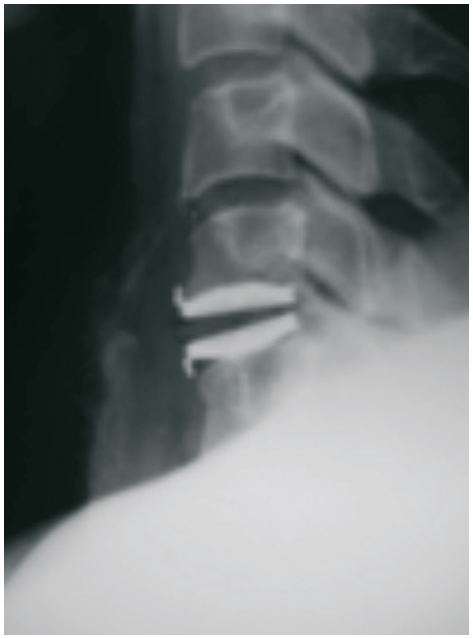
Characteristics of the models in use

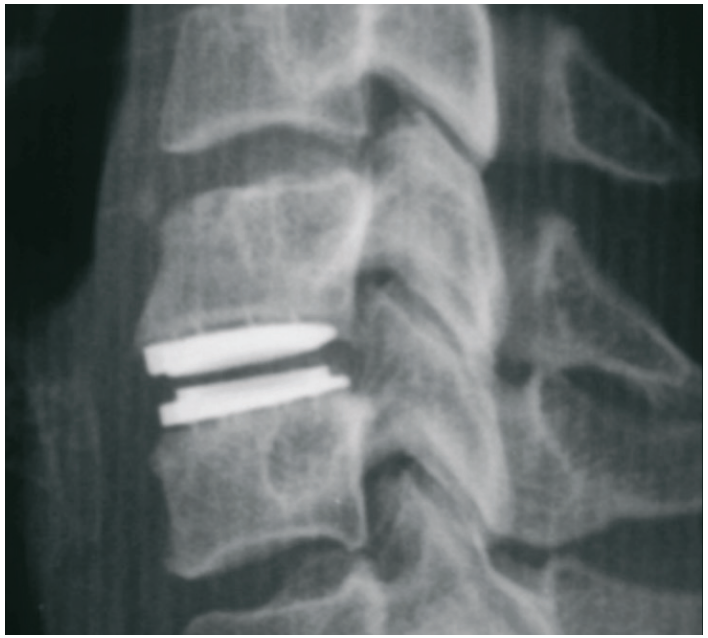
Cervical prostheses can be classified according to the composition of their components and according to their movement parameters.

As regards components, if the implant is metal-on-metal (MOM), this indicates that the articulating surfaces are completely made of metal. The Prestige® LP prosthesis and its previous models are the only ones available in our markets that fulfill this requirement. The rest of the most frequently used prostheses are metal-on-polymer (MOP), in which the end metal surfaces are articulated through a polyurethane core, such as Bryan®, or through an ultra-high molecular weight polyethylene, such as Prodisc®-C, Discover® and PCM® (Pracyk and Traynelis, 2005).

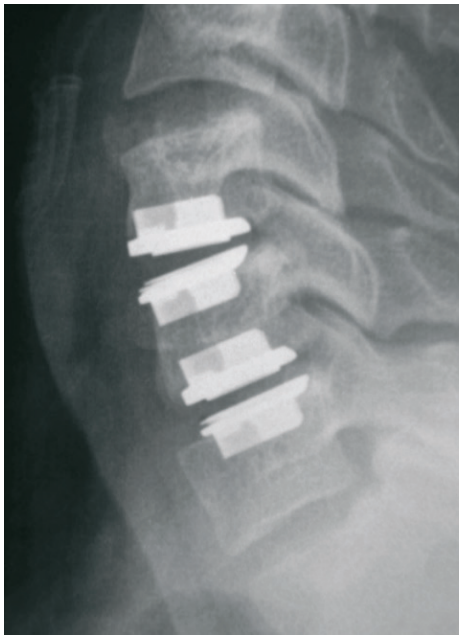
Insofar as movement parameters are concerned, the Bryan® prosthesis is considered non-constrained whereas the Prestige®, Prodisc®-C, PCM® and Discover® prostheses are considered semi- constrained (Hacker, 2006; Pracyk and Traynelis, 2005).



Bryan® MOM, non-constrained.



Discover® MOP, semi-constrained.



Prodisc®-C MOP, semi-constrained.

Different types of prosthesis, depending on movement parameters

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Indications and contraindications

In general terms, the indications for the placement of a disc prosthesis are similar to those for anterior approach discectomy with arthrodesis, where the priority is the retrodiscal pathology with the presence of soft hernias and where it can be demonstrated that the segment being addressed still has motion (Hacker, 2006).

Indications for placement are listed below (Buchowski, Anderson, Sekhon and Riew, 2009; Riew et al., 2008):

- radiculopathy attributable to degenerative disc disease at one, two or three levels;
- myelopathy secondary to disc degeneration with minimal changes due to spondylosis at one, two or three levels with retrodiscal spinal cord compression;
- imaging evidence of a cervical disc herniation or spondylosis at one, two or three levels where segment movement can be demonstrated;
- symptoms associated with segments C3 to C7;
- failure of appropriate medical treatment within at least six weeks but, more frequently, within at least three months.

Contraindications for placement are listed below (Anakwenze et al., 2009; Buchowski et al., 2009; Murrey et al., 2008):

- instability;
- severe spondylosis with disc height loss and movement of less than 2°;
- congenital stenosis;
- ossification of the posterior longitudinal ligament;
- myelopathy of any cause with retrovertebral compression;
- axial cervical pain as the only symptom;
- osteoporosis;
- history of recent cervical infection;
- morbid obesity that impedes an anterior cervical approach;
- the impossibility of X-ray observation of the segment undergoing surgery.

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3. SURGICAL TECHNIQUE

A high percentage of complications during and after surgery are not secondary to poor design or failure of the implant per se, but rather to a lack of experience, poor planning or inadequate selection of subjects for this technique.

There are general similarities between anterior arthrodesis of the cervical spine and the placement of a cervical prosthesis. However, it should be noted that there are important differences that make this type of surgery more demanding and thus more pre-operative planning is necessary to obtain a good outcome.

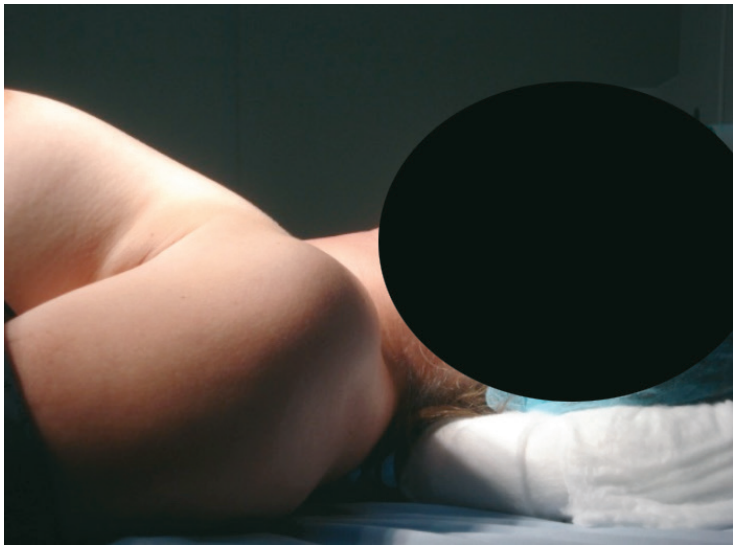
A radiolucent operating table, which allows clear anterior and lateral imaging, and a good image intensifier are required.

Surgical position

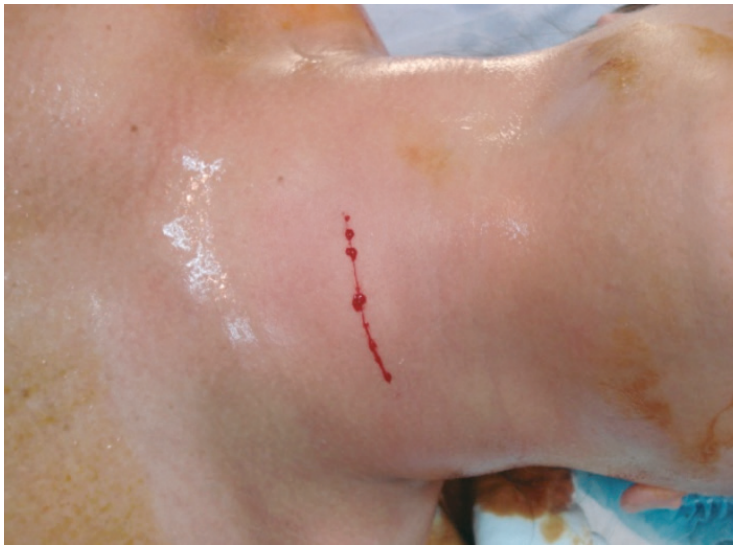
The patient must be in the most physiological position possible. This means that the neck must not be overextended and the head should be in a neutral position, i.e., with no lateral rotation. Ignoring this recommendation can give rise to errors (Buchowski et al., 2009).

- If the spine is overextended, the tendency is for greater resection of the most posterior regions of the vertebral bodies, as they are closed, which increases the risk of developing focal kyphosis when the patient is upright. This has been associated with an increase in the rate of heterotopic ossification.
- If the spine is rotated, radiological identification of the center of the vertebra is difficult and a completely lateral fluoroscopic
- view cannot be obtained. This can result in a prosthesis that is poorly-centered on both the sagittal and coronal planes.

Obese patients or patients with short necks require placement of adhesive tape to pull down the shoulders and obtain an adequate fluoroscopic view of the lower segments, especially C6-C7 and, in some cases, C5-C6.



Without overextension and without rotation.



Anterolateral incision mark.

Surgical position and site marking for approach

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It is recommended to make the incision on the side opposite to the symptomatic side, since this facilitates decompression due to the angle of the microscope.

Approach

Once the levels requiring intervention are identified radiographically, a transverse incision is performed on the side preferred by the surgeon.

This is followed by traditional dissection, as described by Smith- Robinson, until the longus colli muscles are exposed. At this point, and before dissecting these muscles to place the self-retaining retractor, the midpoint between the two muscle bundles should be marked. This almost always coincides with the radiological mark of the midline, thereby saving surgical intervention time (Buchowski, 2009).

Decompression and preparation of the area

Once the approach has been completed, radicular or spinal cord decompression is performed, followed by preparation for the placement of the prosthesis.

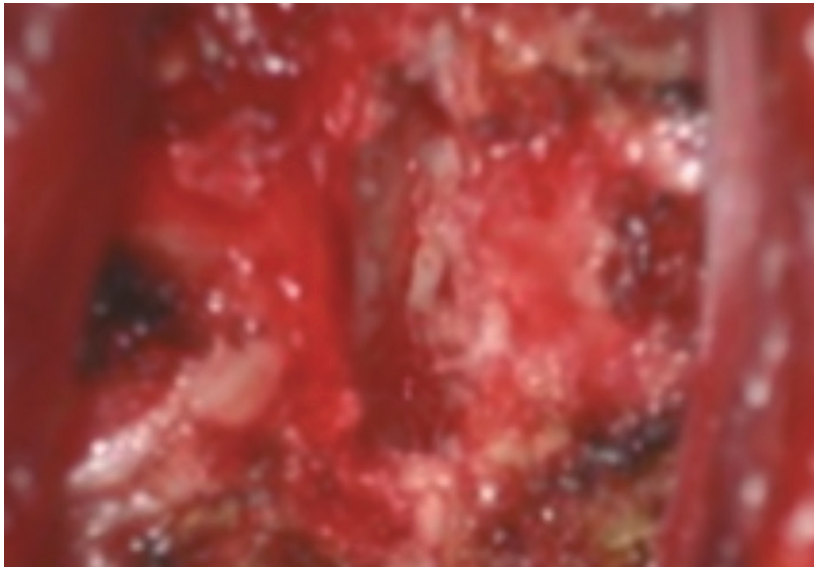
- Decompression is started, resecting the anterior osteophytes with rongeurs and then removing the disc with pituitary forceps. The spinal canal is decompressed with the aid of a microscope.

Appropriate and comfortable position of the microscope for surgery.

Positioning the microscope

- Normally, it is not necessary to cut the posterior longitudinal ligament. However, it must be opened in cases of large extruded hernias with fragments behind the ligament (Bertagnoli, 2005; Murrey et al., 2008).
- Kerrison forceps measuring 2 and 3 mm are then used to remove the posterior osteophytes.
- It is recommended to place bone wax on the edges where the osteophytes have been resected to prevent heterotopic ossification (Buchowski, 2009).

Contrary to the arthrodesis technique, this step must be much more radical when placing a prosthesis, since preservation of segment movement may be accompanied by osteophyte growth over time (Buchowski, 2009).



View of the intervertebral space to complete decompression.

Intra-operative view

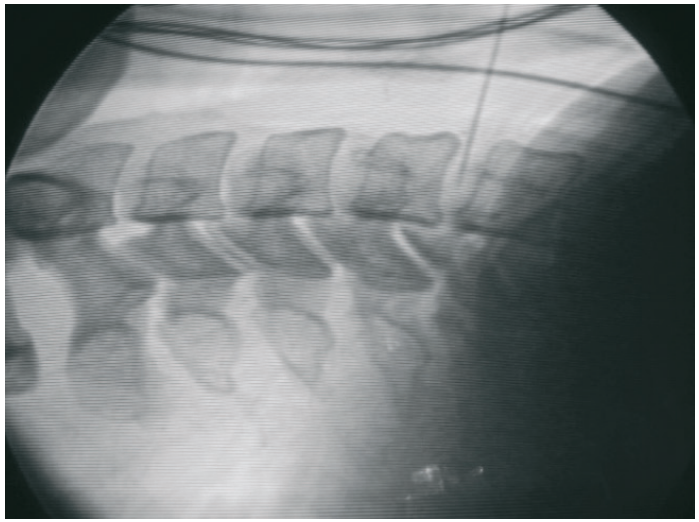
The surfaces of the endplates must be prepared carefully, without weakening them to prevent implant subsidence (Bertagnoli et al., 2005).

It is important to remember that this preparation step differs for each type of prosthesis and to follow the manufacturer's recommendations (Buchowski et al., 2009).

Placement of the prosthesis

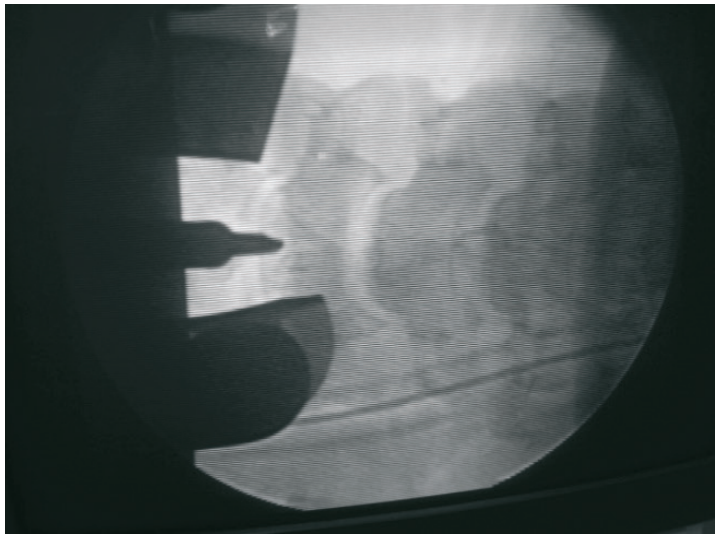
Although specific techniques are used for each implant, all prostheses require the placement of intervertebral disc retainer with the screws placed on the upper third of the upper body and on the lower third of the lower body.

- The screws must be inserted under fluoroscopy, ensuring that they are parallel to the vertebral endplates and near bicortical placement, to ensure that the forces exerted by the retainer are parallel. This will have a positive influence on how the arthroplasty functions (Bertagnoli et al., 2005).



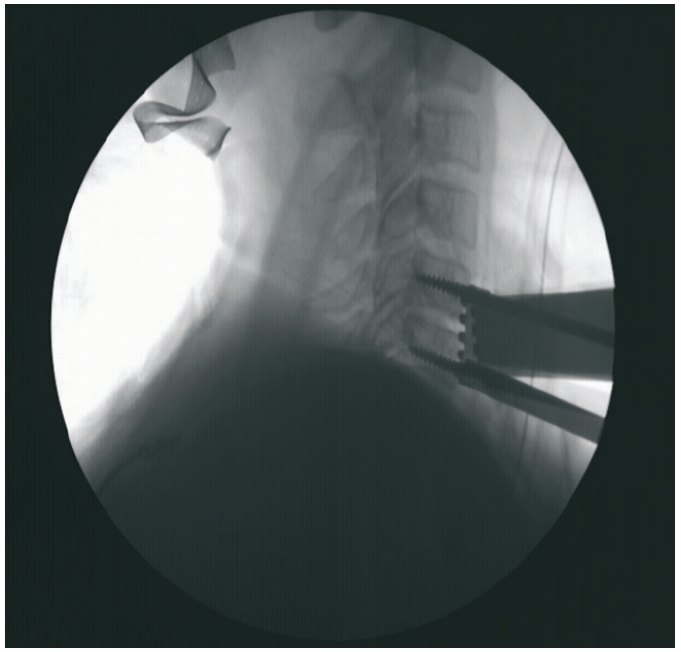
Lateral identification of the disc space to operate on.

Radioscopic monitoring to identify the space and the midline



Anteroposterior view of the midline before placement of the prosthesis.

Radioscopic monitoring to identify the space and the midline



Proper placement of the screws of the spacer: the position should be parallel to the vertebral endplates.

Radioscopic monitoring of the intervertebral spacer

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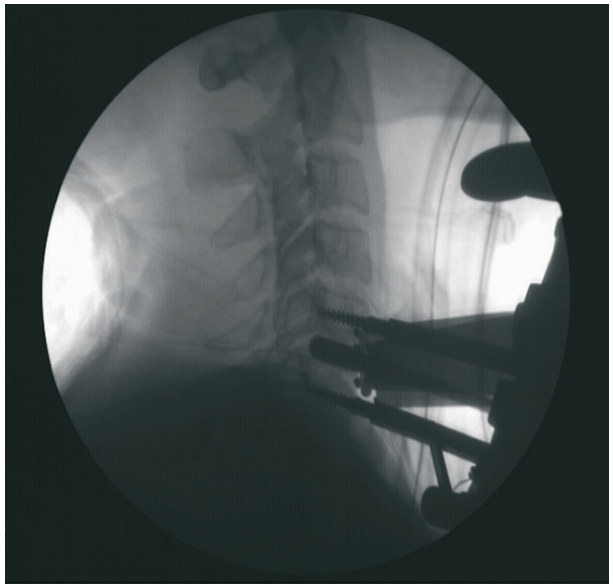
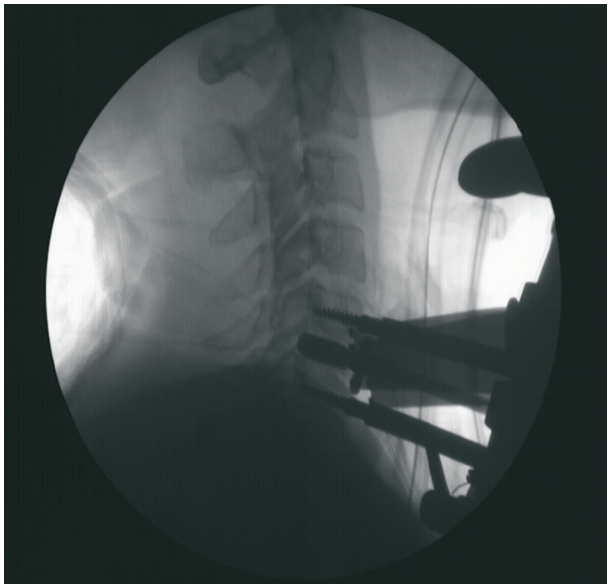
- The next step is to insert the tools used to select the appropriate prosthesis. This involves choosing the size that best fits the height, width and depth of the intervertebral space.

A common error, especially in first attempts, is not placing the prosthesis on the posterior edge of the disc space. This can be secondary to inadequate decompression or fear of causing a spinal cord injury.

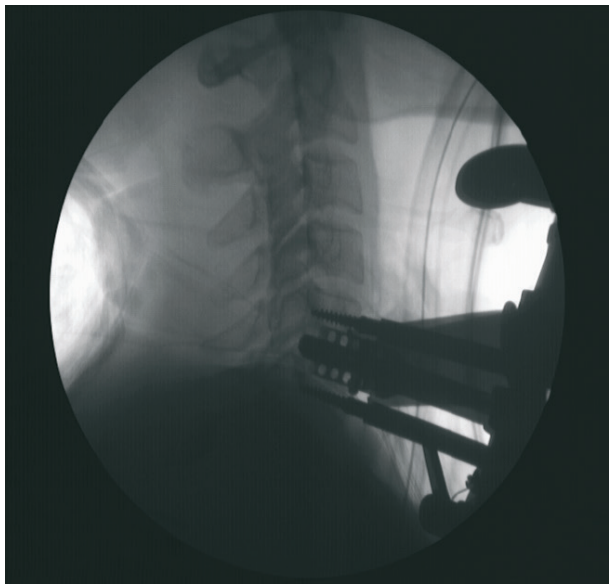
Note that it is ideal for the prosthesis to cover, as best as possible, the three dimensions, preventing displacement, subsidence or over-distraction, which would result in a poor clinical outcome.



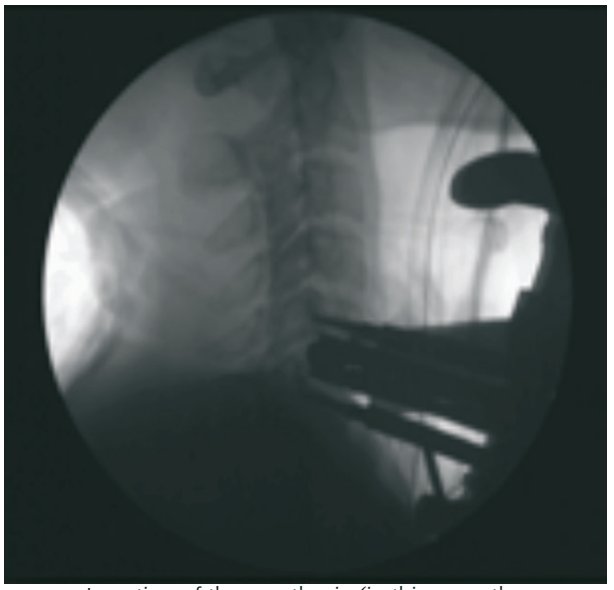
Insertion of the prosthesis sizer to determine the correct position.



Location where the implant should be placed.



Insertion of the chisel.



Insertion of the prosthesis (in this case, the Prodisc®-C model, semi-constrained with keel).

Radioscopic monitoring: placement details

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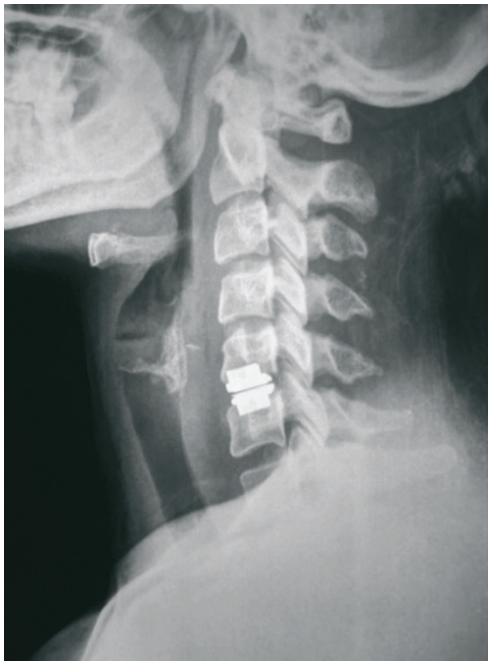
Post-operative management

If no complications arose during surgery or immediately after surgery, and as long as post- operative X-rays indicate the correct position of the prosthesis in both the sagittal and coronal planes, then the patient can get up six to seven hours after the procedure. The patient can usually be discharged after one day of hospital stay.

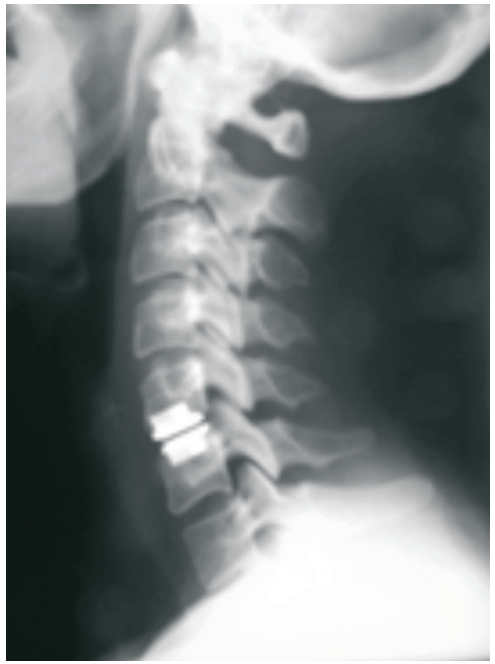
Post-operative pain can be managed with common analgesics or occasionally with opiates (Murrey et al., 2008) and there is no need for a collar of any kind, unless the patient complains of cervical pain (rare).

Patients who perform physically demanding work should not return to full activity for one month; however, in most other professions, patients return to work within an average of between three to ten days. On the other hand, some patients require a short cycle of physiotherapy, although this is not routine.

Initial X-rays commonly reveal inadequate sagittal alignment, a phenomenon that resolves itself over time and as the patient stops taking analgesics and returns to their daily activities.



Loss of lordosis is visible in the immediate post-operative period.



Improved sagittal plane is visible six months after surgery.

Post-operative X-rays

Possible complications

Complications in this type of surgery can be associated with the approach and the implant (Denaro et al., 2009).

The complications due to the approach do not differ from those reported in anterior approach fusion surgery. The rates of incidents are similar and there are even reports of a lower rate of dysphagia with the use of a prosthesis, compared to discectomy performed with arthrodesis and a plate.

Complications associated with the implant are rare and less serious, if compared with lumbar prosthesis surgery. Revision surgery is less demanding and involves less risk (Denaro et al., 2009).

Poor implant position	This can occur in both the sagittal and coronal planes. Poor positioning of any kind must be diagnosed in the immediate post-operative period and corrected, relocating the same prosthesis or replacing it if the choice was inappropriate. Less frequently, it may be necessary to transform the procedure into fusion surgery.
Fracture of vertebral body	This has been reported with the use of a muti-level prosthesis using Prodisc®-C with a keel. The recommendation is to avoid these types of implants in patients with a certain degree of osteopenia (women over 45 years old) or short individuals with small vertebral bodies. In addition, the use of the milling device vs the keel cutting chisel has minimized this risk. The problem is resolved with the use of the new Prodisc®-C with 3 smaller keels.
Infection	Infections can be classified as superficial or deep. Conventional antibiotic treatment and local hygiene measures are generally sufficient for superficial infections. However, if the infection is deep, this may involve compromise of the adjacent vertebral bodies or an epidural abscess. This requires revision surgery with the removal of the implant and a complementary arthrodesis.
Heterotopic ossification	This is the most frequently reported late complication. It does not usually alter the clinical outcome. It has been classified by McAfee into five classes (0-IV), where 0 is negative and IV corresponds to inadvertent and unplanned arthrodesis (Mehren et al., 2006). Some authors have recommended the use of NSAIDs in the post-operative period to prevent it. However, it is more likely to be associated with a poor surgical technique, as mentioned above (Hacker, 2006; Mehren et al., 2006).
Subsidence	Subsidence is rarely reported in the cervical spine, but is directly associated with a poor surgical technique that causes excessive weakening of the endplates.
Debris and loosening	Little is known about this factor, especially as regards the cervical spine, that will become increasingly important in the future.

Expected outcomes

In a proper selection of patients, the clinical outcomes that have been reported are similar to those obtained by anterior approach arthrodesis (Bertagnoli et al., 2005; Murrey et al., 2008).

The important question is whether movement preservation can also reduce the incidence of surgery to the same degree as in the adjacent segments.

To date, some articles on a five-year follow-up report that the number of re-interventions of statistical significance, regarding both the level operated on and adjacent levels, is lower in the prosthesis group than in the arthrodesis group (Murrey et al., 2008). This has not occurred in all the prospective studies.

Other important aspects requiring discussion is the indication for prosthesis in multiple levels when the main symptom is myelopathy, and when presented as an alternative for treatment on a level adjacent to an arthrodesis.

- It is currently accepted that a good indication for prosthesis placement is a pathology that affects as many as three levels (Riew et al., 2008).

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- If myelopathy is secondary only to retrodiscal pathology, this is a good indication for the placement of a prosthesis. Most patients who fall into this group are relatively young, thus excluding the elderly, and present spinal cord compromise secondary to severe spondylolysis with retrocorporal pathology that does not require this technology.

- The last group of patients of recent and growing interest are those with symptomatic pathology at superior or inferior levels adjacent to a previous arthrodesis. Prosthesis can be considered an option in these cases when the level requiring treatment fulfils the same primary indication and contraindication requirements; however, it is also important to consider that if the segment is hypermobile, the arthroplasty technique should be used with numerous restrictions, as there is a high possibility of mechanical failure (Phillips et al., 2009).

4. Summary

Summary:

Although it is true that anterior cervical ar throdesis continues to be the surgery of choice to resolve the conditions caused by degenerative pathology of a large percentage of patients, techniques that do not require fusion, specifically cer vical arthroplasty, have gained ground in recent decades.

This is based on the hypothesis that preservation of movement of the segment to be treated achieves a good, early post- operative outcome and reduces the incidence of degeneration in the adjacent segments in the mid- and long-term. The first goal has been widely demonstrated in the literature, with results similar to those for arthrodesis. However, the second and most important goal continues to be highly controversial; although some groups have reported a lower incidence of secondary surgery in patients receiving a prosthesis compared to those undergoing arthrodesis.

To obtain good outcomes with this type of implant, it is essential to be fully aware of the indications and, above all, the contraindications. There is a high probability of success and high patient and surgeon satisfaction if the following aspec ts are controlled:

- mastery of the surgical technique;
- clear identification of the differences between this technique and arthrodesis;
- precise knowledge of the details specific to each prosthesis model on the market.

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Project coordination
Néstor Fiore
Luciana Braga Garcia

Instructional design and educational review
María Alejandra Zangara
María Eugenia Bregliano

Project and graphic design
André Secundino

AOSPINE

Advancing spine care worldwide

AOSpine International
Stettbachstrasse 6
8600 Duebendorf
Switzerland

T +41 44 200 2409
F +41 44 200 2412
education@aospine.org
www.aospine.org