

Interspinous implants and pedicle screws for dynamic stabilization of lumbar spine: Rapid assessment

KCE reports 116C

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Executive summary

This rapid assessment concerns the clinical effectiveness and the efficiency of innovative surgical technologies proposed for the treatment of degenerative spinal conditions: interspinous spacers and pedicle screw systems. These techniques are presented as an alternative to decompression surgery (laminectomy or discectomy) and/or fusion surgery. Currently, none of these implants are officially reimbursed in Belgium. However, in practice, a specific reimbursement can be obtained for some elements of the pedicle screw systems (cords and pedicle screws).

This report follows the standard methodology of HTA reports of the KCE, without deeply considering patient issues, ethical issues and organisational issues.

INTERSPINOUS IMPLANTS

BACKGROUND

Lumbar spinal stenosis (LSS) is a narrowing of the spinal canal, resulting in low back pain and sciatica, exacerbated with walking (neurogenic intermittent claudication). Conservative treatment (physical therapy, analgesics, NSAIDs, and epidural steroid injection) is often the first choice of treatment. For patients who had failed at least six months of non-operative therapy, surgery can be performed to decompress the nerve roots, laminectomy being the gold standard.

Interspinous implants, inserted between adjacent spinous processes at the level of spinal stenosis in order to enlarge the neural foramen as the spinal canal, are presented as a less invasive alternative. A lot of interspinous devices are currently in use on the international market (X STOP, Wallis, DIAM, ExtenSure, Coflex, Aperius PercLID, InSwing, InSpace, BacJac). Generally, interspinous implants are in one block, either out of titanium, or out of rigid materials (polyetheretherketone [PEEK]), or out of flexible materials (polyurethane covered with woven polyester or flat bands of woven polyester). Until now, only one device (the X STOP, Medtronic) is approved by the FDA. The X STOP consists of an oval titanium spacer for which clinical indications remain relatively vague.

OBJECTIVES

The objective of this rapid assessment is to synthesize available clinical and economic evidence about main interspinous devices used in Belgium (X STOP, Wallis, DIAM and Coflex), compared to conservative treatment or decompressive surgery for following indications: lumbar spinal stenosis, degenerative spondylolisthesis, lumbar herniated disc or low back pain that failed to respond to conservative treatment of at least 6 months.

METHODS

An iterative search strategy was performed, first searching for existing health technology assessments (HTA) and systematic reviews on specific websites (national HTA agencies, databases of Centre for Reviews and Dissemination [CRD], Cochrane Library, Medline and Embase). Subsequently, randomized controlled trials (RCTs) and primary studies published between 1980 and 2009 were searched for in Cochrane Library, Medline and Embase. Finally, the grey literature was searched via Google, Google Scholar, FDA and EMEA websites, and via contacts with suppliers and manufacturers of lumbar non-fusion posterior stabilization devices.

All potentially relevant papers were selected on titles and abstracts by 2 independent reviewers. The quality of the selected papers was assessed by one reviewer on the basis of the full-text, using standardized checklists (the INAHTA checklist for HTA reports, checklist of the Dutch Cochrane Centre for RCTs and checklist of CRD for prospective before-and-after-studies). Poor quality studies were excluded from further review. Following data were retrieved from selected clinical studies: study design, patients population, type of intervention, comparator, clinical effectiveness, safety and follow-up.

RESULTS

Clinical effectiveness and safety

Eight publications were included in our analysis: 1 HTA report, 1 Interventional Procedures Guidance (NICE), 2 RCTs and 4 prospective before-and-after studies without comparator. Only publications studying X STOP or Wallis were retrieved. No high quality publication allowed us to assess DIAM and CoFlex.

The HTA report and the Interventional Procedures Guidance published by NICE were mainly based on a randomized controlled trial conducted on X STOP by the inventors of this device in USA (Zucherman et al. 2005). The other included studies in these two reports were prospective before-and-after studies without comparator, conducted on small sample sizes. In the Zucherman's trial, 100 patients received the implant X STOP and 91 controls were allocated to a non standardized conservative treatment, that was followed at least 6 months before patients' enrolment in this trial. This study concluded to the higher effect of X STOP on pain relieving 2 years after the surgical intervention (60% vs. 18%), on physical function (walking ability ; 57% vs. 15%) and on patients' satisfaction (73% vs. 36%). However, 6 patients in the X STOP group and 24 patients in the control group underwent decompressive surgery (laminectomy) for unresolved stenosis symptoms during the 2 year follow-up period. Moreover, a significant percentage of patients whose symptoms improved at six and twelve months showed a trend of regression of pain and physical function symptoms toward baseline levels. There were many methodological problems with this randomized clinical trial that questioned the reliability of results.

Subsequent studies using a control group (Anderson et al. 2006 and Hsu et al. 2006) were follow-up studies of the original Zucherman's trial and were conducted by the same researchers, suffering from the same weaknesses.

The prospective before-and-after studies conducted by other researchers on two interspinous devices (X STOP and Wallis), with a mid-term follow-up (1 to 3 years) also reported an improvement in scores for pain, physical function and walking distance. However, these scores were always obtained on self-reported questionnaires and clinical significance of results was never discussed. Moreover, only a proportion of patients population reported an improvement (~60%) whereas other patients further require analgesics use (29% one year after X STOP, 58% three years after Wallis insertion) or a more invasive surgical intervention such as laminectomy and/or fusion (4.6% to 9.2% according to studies). Complications associated with the device implantation were wound dehiscence, wound swelling, hematoma, infection, incision pain and device migration.

It is striking to note that there are no clear-cut clinical indications, and that studies included patients suffering from very heterogeneous pathologies. For example, a high failure rate was recorded (58%) in patients with degenerative spondylolisthesis (Verhoof et al. 2008). Rigorous studies with a sufficient statistical power are needed to draw firm conclusions about the effectiveness of interspinous implants. Around ten RCTs are currently ongoing.

PEDICLE SCREWS

BACKGROUND

Degenerative spondylolisthesis is an acquired anterior displacement of one vertebra over the subjacent vertebra. It is most common at the L4-L5 level of the lower spine. The conservative treatment (NSAIDs in increasing pain, physiotherapy) remains the first treatment in the symptomatic spondylolisthesis, without neurologic impairment. Surgical treatment of spondylolisthesis remains a complex and controversial issue. Reference treatment considers surgical decompression with/without fusion of vertebrae if the slippage is important. In this procedure, two or more vertebrae are permanently fused together, using a bone graft (either autograft or allograft). Screws and rods are sometimes used to hold the spine in place, making the fusion of the bones happen faster.

Pedicle screw systems are proposed as alternatives to invasive surgery. Diverse pedicle screws systems are used in the international market (Graf ligament, Dynesys, Isobar, DSSS, M-brace, TFAS and TOPS). The main pedicle screw system used in Belgium, i.e. the Dynamic neutralisation system (Dynesys Spinal System), will be considered in this report. The other devices, which are not extensively studied in the scientific literature, will not be assessed here.

Already commercialized in Europe and experimentally used in USA, Dynesys consists of titanium alloy screws, polyester cords, and spacers between screw heads. The stabilising cord connects the pedicle screw heads through a hollow core in the spacers and holds these in place. Thus, the Dynesys is designed to preserve the natural function of the spine by allowing motion and sharing in-load transmission.

The product's label indicates Dynesys is intended to provide immobilization and stabilization of spinal segments in the treatment of degenerative spondylolisthesis with objective evidence of neurologic impairment.

OBJECTIVES

The objective of this rapid assessment is to synthesize available clinical and economical evidence about Dynesys, compared to conservative treatment, decompressive surgery and/or fusion for following indications: lumbar spinal stenosis, degenerative spondylolisthesis, lumbar herniated disc or low back pain that failed to respond to conservative treatment for at least 6 months.

METHODS

Methodology used was the same as explained in study about interspinous implants.

RESULTS

Clinical effectiveness and safety

Six publications on Dynesys were included in our analysis: 1 HTA report, 1 Interventional Procedures Guidance (NICE) and 4 prospective before-and-after studies without comparator. No randomized clinical trial was identified.

Recent before-and-after studies (without comparator) reported significant improvements in back and leg pain, pain severity, quality of life, walking distance (> 1000 m) and return to work. Despite these encouraging results, 15 to 20% of operated patients further required a surgical re-intervention for diverse reasons (insufficient decompression, radiculopathy, increased pain or instability), needing device removal.

Because these procedures were always undertaken concurrently with surgical decompression, it is difficult to ascertain what clinical benefit is derived from the implants themselves. Follow-up remained confined to short-term (1-2 years). Only one study (Schaeren et al. 2008) reported a 4 year follow-up in a small sample (n=26 patients). At 4 years, positive results remained unchanged (decreasing pain and decreasing use of analgesics, increasing walking distance).

However, 47% of the patients showed new signs of degeneration at adjacent levels. Some authors observed less positive results than those obtained with fusion, others reserved this treatment in preventing post-nucleotomy segmental degradation.

Main complications associated with pedicle screws insertion are neurologic and vascular: malpositioned screws, broken screws leading to screw loosening. Whereas this procedure is theoretically considered as a minimally invasive approach, surgical implantation of pedicle screw devices is as invasive as fusion, with resulting disruption of the muscle and ligamentous structures.

While Dynesys was conceived to dynamically stabilize the lumbar spine, this device was approved by FDA as an adjunct to fusion. New studies for a non fusion application are currently going on in the United States.

ECONOMIC EVALUATION

LITERATURE REVIEW

No full economic evaluation of interspinous implants and pedicle screw systems was identified. Only one cost-minimisation analysis and one cost-outcome comparison were identified from the literature review and the quality of these studies was insufficient to draw credible conclusions.

The impact of non fusion lumbar dynamic stabilization implants on outcomes such as the operative time, the hospitalization length, the quality-adjusted life-years (QALYs) and long term costs due to complications and re-hospitalizations is unknown from the Belgian setting.

Given the lack of evidence on clinical effectiveness of interspinous implants and pedicle screw based systems, no credible cost-effectiveness analysis can be performed. Moreover, given the lack of data about the prevalence of these affections (clinical indications) and given the lack of data about frequency of surgical interventions for decompression and stabilization (dynamic stabilization or fusion) of lumbar spine, it is impossible to estimate the budget impact of a hypothetical reimbursement of these new surgical technologies for our country.

INTERNATIONAL COMPARISON

The prices of each device (including VAT) applied in Belgium was compared to mean prices calculated for 5 neighboring countries (France, Germany, Switzerland, The Netherlands and UK). In Belgium, the price for dynamic stabilization implants is close to the price applied in the 5 neighboring countries and approximates 2 500€, for the X STOP as for the Dynesys. However, no study allows to confirm that this price is justified compared with the real costs.

Different reimbursement mechanisms are used in all countries, from a non mandatory reimbursement (The Netherlands) to a DRG system using specific procedures codes in order to globally cover the implant and the surgical procedure (UK). In Belgium, none of these implants are officially reimbursed. However, in practice, a specific reimbursement can be obtained for some elements of the pedicle screw systems (cords and pedicle screws).

CONCLUSIONS

- There is low quality evidence on the clinical effectiveness of lumbar non fusion dynamic stabilization for the treatment of degenerative pathologies of the lumbar spine.
- Given the lack of evidence on clinical effectiveness of lumbar non fusion dynamic stabilization implants, no credible cost-effectiveness analysis can be performed.
- Given the lack of data about the prevalence of these affections (clinical indications) and given the lack of data about frequency of surgical interventions for decompression and stabilization (dynamic stabilization or fusion) of lumbar spine, it is impossible to estimate the budget impact of a hypothetical reimbursement of these new surgical technologies for our country.

RECOMMANDATIONS

- At present and until the results of high-quality primary research become available, the lumbar non fusion dynamic stabilization devices have to be considered experimental, and should ideally be limited to randomized clinical trials.
- Randomized prospective studies, in which devices are compared to adequate comparators (standardized non surgical treatment and decompressive surgery), conducted on carefully selected patients (limited list of clinical indications), with a long follow-up (> 5 years) and assessment of objective clinical outcomes (e.g. real assessment of walking distance and walking duration without pain, use of generic assessment of quality of life, return to work or return to previous activities) are needed to define the place of these devices as therapeutic means in the degenerative lumbar spine surgery.
- Current evidence on the safety of these procedures remains unclear. It is recommended to systematically notify to the Federal Agency for Medicines and Health Products all complications observed by device.
- Given the poor quality of evidence on long-term clinical advantages; given the fact that numerous RCTs are ongoing for different lumbar non fusion dynamic stabilization devices, and given the lack of economic data, we do not recommend to include interspinous devices and pedicle screw based devices in the limitative list of reimbursed implants (currently ongoing by the NIHDI).

Scientific summary

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GLOSSARY

95% CI	95% confidence intervals
CLBP	Chronic low back pain
DDD	Degenerative disk disease
DRG	Diagnosis-Related Groups
FDA	Food and Drug Administration
GHS	Groupe homogène de séjour
HRG	Healthcare Resource Group
HTA	Health technology assessment
ICER	Incremental cost-effectiveness ratio
IDE	Investigational Device Exemption
LBP	Low back pain
LPP	Liste des produits et prestations remboursables
LSS	Lumbar spinal stenosis
MRI	Magnetic Resonance Imaging
NASS	North American Spine Society
NIC	Neurogenic intermittent claudication
NIHDI	National Institute for Health and Disability Insurance
NSAID	Non-steroidal anti-inflammatory drug
ODI	Oswestry Disability Index
PDS	Posterior dynamic stabilization
PEEK	Polyetheretherketone
PICO	Patient, Interventions, Comparator treatment and Outcomes
PMA	Pre-Market Approval
QALY	Quality adjusted life-year
QoL	Quality of Life
RCT	Randomised controlled trial
RR	Relative risk
VAS	Visual Analog Scale
ZCQ	Zurich Claudication Questionnaire

I INTRODUCTION

This rapid assessment concerns innovative spine surgical technologies, i.e. lumbar non-fusion posterior stabilization devices proposed for the treatment of degenerative spinal conditions with symptoms that have failed to respond to conservative treatments. They are presented as an alternative to decompression surgery and/or fusion surgery.

Numerous lumbar non fusion posterior dynamic stabilization (PDS) devices have been developed for the treatment of disorders of the lumbar spine but they all aim at maintaining or restoring inter-vertebral motion, whether by restricting the extremes of spinal movement or by dampening the kinetic energy involved in motion^{1,2}.

Two main groups of PDS, interspinous spacers and pedicle screw systems, have been in use for almost a decade now outside of North America³. First, interspinous spacer devices are inserted between the spinous processes and have no rigid fixation to the vertebral pedicles, but can be optionally attached with cords. These devices function by “inducing flexion” in the degenerative segment and result in less buckling of the ligamentum flavum, offloading of the facets, and reducing intervertebral disc pressures⁴.

Pedicle screw systems offload spinal units in a fashion similar to pedicle-based posterior instrumentation⁵. They may provide more rigid stabilization and require a more extensive surgical procedure for insertion. The structures connecting the vertebral bodies to one another are flexible and are not intended to provide rigid stability.

In Belgium, some of these PDS are already being placed in more or less 50 hospitals. The aim of this report is to summarize the existing clinical and economic evidence on PDS for patients with specific indications. Based on other existing HTA reports, systematic reviews and clinical trials, the objective is to provide a clear synthesis of the evidence on clinical effectiveness and safety of these emerging technologies.

This report follows the standard methodology of HTA reports of the KCE. However, in contrast to full HTA reports, patient issues, ethical issues and organisational issues will not be addressed. Information on the cost and cost-effectiveness of PDS will be searched through a literature review. However, no cost analysis in the Belgian setting will be performed because of a lack of available data. Indeed, interventions with PDS can not be identified from existing Belgian databases and only proxy and assumptions can be used (low level of quality). Finally, an international comparison will be conducted to compare prices and reimbursement practices concerning PDS in selected European countries to have a better view on their cost for health insurers.

The main research questions are:

Question 1: Is lumbar non-fusion posterior dynamic stabilization a clinically effective treatment for patients with symptomatic lumbar spinal stenosis, degenerative spondylolisthesis, degenerative disc disease, herniated disc or facet joint osteoarthritis?

Question 2: Is lumbar non-fusion posterior dynamic stabilization a safe procedure for patients with symptomatic lumbar spinal stenosis, degenerative spondylolisthesis, degenerative disc disease, herniated disc or facet joint osteoarthritis?

Question 3: Is lumbar non-fusion posterior stabilisation a cost-effective treatment option for patients with symptomatic lumbar spinal stenosis, degenerative spondylolisthesis, degenerative disc disease, herniated disc or facet joint osteoarthritis?

2 BACKGROUND

2.1 GENERAL PRESENTATION OF LUMBAR PATHOLOGIES

An individual vertebra is made up of several parts. The body of the vertebra is the primary area of weight bearing and provides a resting place for the fibrous discs which separate each of the vertebrae. The lamina covers the spinal canal. There are four facet joints associated with each vertebra. These interlock with the adjacent vertebrae and provide stability to the spine. The facet joints do slide on each other and both sliding surfaces are normally coated by a very low friction, moist cartilage. A small sack or capsule surrounds each facet joint and provides a sticky lubricant for the joint. Each sack has a rich supply of tiny nerve fibres that provide a warning when irritated⁶.

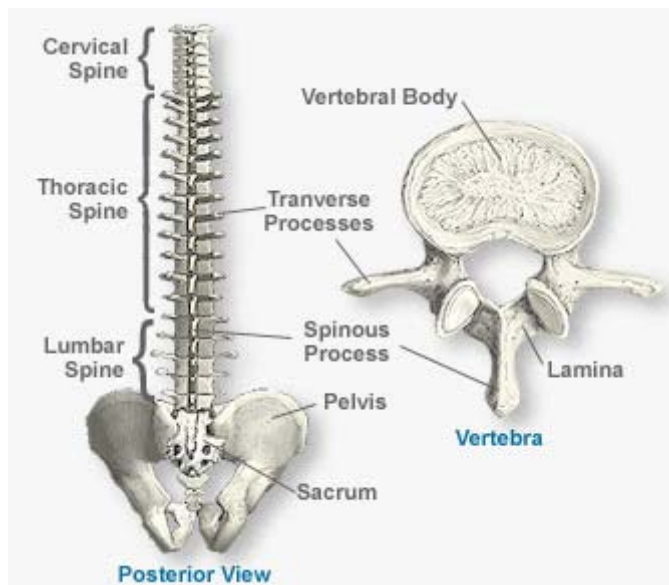


Illustration from: <http://www.scoi.com/spinanat.htm> (Available in June 2009)

The vertebrae are separated by intervertebral discs which act as shock absorbers for the vertebrae, allowing motion to occur between them. Separation between the vertebral bodies is maintained by the height of the disc, which also allows the segmental nerve roots to exit without compression.

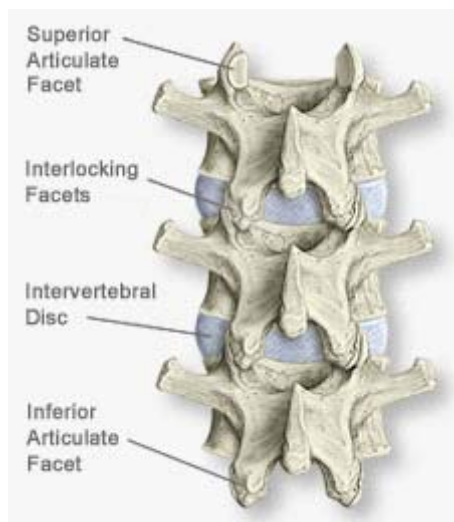


Illustration from: <http://www.scoi.com/spinanat.htm> (Available in June 2009)

2.1.1 Lumbar herniated disc

A prolapsed disc occurs when the disc is displaced, herniated or bulging from its normal position within the spinal column. The disc may place pressure on the nerve root (radiculopathy) and cause symptoms such as radiating pain, numbness, tingling and weakness. Approximately 90% of disc herniations will occur toward the bottom of the spine at L4-L5 or L5-S1, which causes pain in the L5 nerve or S1 nerve, respectively.

2.1.2 Isthmic spondylolisthesis

Spondylolisthesis is a forward slip of one vertebral body over the one below. The isthmic spondylolisthesis occurs when one vertebral body slips forward on another because of a small fracture of the pars interarticularis. Isthmic spondylolisthesis occurs most commonly in the L5-S1 level of the spine. The spondylolisthesis can be graded according to the severity of the slippage of one vertebral body over another (Grade 1 is less than 25%; Grade 2 is 25-50%; Grade 3 is 50-75%; Grade 4 is greater than 75%).

Between 5 to 7% of the population has either a spondylolysis (a fracture of the pars interarticularis without a vertebral slip) or spondylolisthesis, but in most cases it is asymptomatic. It has been estimated that 80% of people with a spondylolisthesis will never have symptoms, and if it does become symptomatic, only 15 to 20% will ever need surgical correction⁷. Isthmic spondylolisthesis may also become symptomatic in adults. The most common reason for low back pain in this situation is that the disc will start to wear out. Also, as the discs break down, there is less room for the exiting nerve root (the L5 nerve root) and the patient can develop leg pain (radiculopathy or sciatica).

2.1.3 Facet joint osteoarthritis

Facet joints are in almost constant motion with the spine and quite commonly simply wear out or become degenerated in many patients. When facet joints become worn or torn the cartilage may become thin or disappear and there may be a reaction of the bone of the joint underneath producing overgrowth of bone spurs and an enlargement of the joints. Such osteoarthritis can produce considerable back pain on motion. This condition may also be referred to as “facet joint disease” or “facet joint syndrome”. Recurrent painful episodes can be frequent and quite unpredictable in both timing and extent.

2.1.4 Lumbar spinal stenosis

Lumbar spinal stenosis (LSS) is a narrowing of the spinal canal, often secondary to degenerative changes in the disc and the adjacent facet joint.

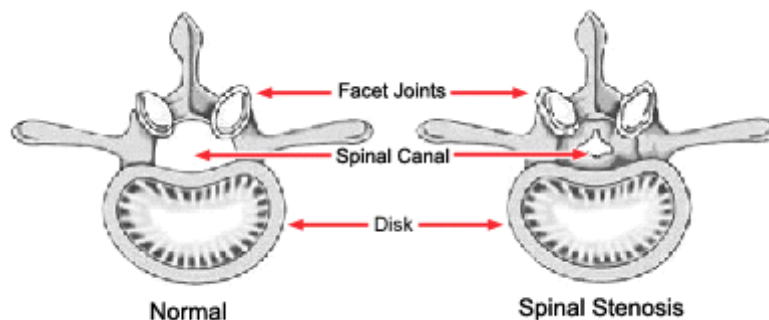


Illustration from: <http://orthoinfo.aaos.org/topic.cfm?topic=A00329> (Available in June 2009)

Typically, patients with LSS have a long history of pain in the back, buttocks, and/or legs that gradually worsens over time. The proposed pathological mechanism for radicular pain is thought to be one of ischaemia analogous with the vascular claudication of the lower limbs. Activity increases the blood supply with possible functional and postural changes in cross-section area of the spine, with the potential to reduce the volume of the spinal canal. This leads to a functional ischaemia which gives rise to neurogenic intermittent claudication (pain initiated by standing and increased with walking). Although not all symptomatic LSS leads to neurogenic intermittent claudication, its characteristic symptoms include back and leg pain, tingling, numbness and weakness. Although symptoms may arise from narrowing of the spinal canal, not all patients with narrowing develop symptoms. The reason why some patients develop symptomatic stenosis and others do not is still unknown. Therefore, LSS does not refer to the pathoanatomical finding of spinal canal narrowing. It is a clinical syndrome of lower extremity pain caused by mechanical compression on neural elements or their vascular supply⁸.

2.1.5 Degenerative spondylolisthesis

Degenerative spondylolisthesis is an acquired anterior displacement of one vertebra over the subjacent vertebra, associated with degenerative changes, without an associated disruption or defect in the vertebral ring⁹. It is most common at the L4-L5 level of the lower spine, but can also happen at L3-L4. It is relatively rare at the other levels. It may also occur at two levels or even three levels of the spine.

The symptoms of a degenerative spondylolisthesis are very commonly the same as that of spinal stenosis. Patients usually complain of sciatica pain or a tired feeling down the legs when they stand for a prolonged period of time or try to walk any distance (pseudoclaudication). The nerve root pinching can lead to weakness in the legs, but true nerve root damage is rare. If the stenosis becomes very severe, or if the patient also has a disc herniation, they can develop cauda equina syndrome where there is progressive nerve root damage and loss of bladder/bowel control. This is a very rare clinical syndrome, but is a medical emergency.

2.1.6 Degenerative disk disease

Degenerative disc disease (DDD) is part of the natural process of growing older. Intervertebral discs lose their flexibility, elasticity, and shock absorbing characteristics. The ligaments that surround the disc called the annulus fibrosis, become brittle and they are more easily torn. At the same time, the nucleus pulposus starts to dry out and shrink. The combination of damage to the intervertebral discs, the development of bone spurs, and a gradual thickening of the ligaments that support the spine can all contribute to degenerative arthritis of the lumbar spine. The most common symptom of degenerative disc disease is back pain. When DDD causes compression of the nerve roots, the pain often radiates down the legs or into the feet, and may be associated with numbness and tingling. In severe cases of lumbar DDD, where there is evidence of nerve root compression, individuals may experience symptoms of sciatica and back pain, and sometimes even lower extremity weakness.

3 EPIDEMIOLOGY OF DEGENERATIVE CONDITIONS OF THE LUMBAR SPINE IN BELGIUM

In young and middle-aged adults (20–60 years old), radicular pain is usually caused by lumbar herniated discs or isthmic spondylolisthesis. In elders (over 60 years of age), facet joint osteoarthritis, lumbar spinal stenosis and degenerative spondylolisthesis are the main causes of radicular pain. Most of these pathologies have chronic low back pain as a common symptom (CLBP), so as the epidemiology of degenerative conditions of the lumbar spine in Belgium can be reasonably appraised by looking at the epidemiology of CLBP.

- Based on the INTEGO database (subsidized by the Agentschap Zorg & Gezondheid [Agency Care & Health]; coverage: 3 851 patients in 2004), the yearly incidence of CLBP in general practice was 33.1 per 1 000 practice population in 2004-2006 (<http://www.intego.be/> accessed on 13/07/09). Other figures come from population surveys. The Belgian Health Interview Survey (HIS) found a yearly prevalence of serious back problems of 9.5% for men and 10.4% women over the years 1997, 2001 and 2004 (<http://www.iph.fgov.be/scripts/broker.exe> accessed on 13/07/09)
- The minimal clinical data and the claim data (NIHDI) are also important sources of information, as reviewed in the KCE report 48B¹⁰. We report here the main findings of that report as regards the incidence and distribution of CLBP. We acknowledge that the situation may have evolved slightly since 2004, but these results are still indicative of the problem size in our country.
- Approximately 85 000 hospital stays (40 000 classic hospitalizations and 45 000 in one-day hospital) for low back pain were recorded in the 2004 Minimal Clinical Database.
- The most frequent diagnoses in classic hospitalization were herniated disc (38.7%), probable degenerative diseases (14.4%), spinal stenosis (13.6%), and Failed Back Surgery Syndrome (10.5%). The remainder was constituted by non-specific diseases.
- In 2004, 12 786 discectomies, 5 384 fusions and 4 770 laminectomies interventions were performed, while the NIHDI nomenclature data indicate that 17 604 surgical interventions were performed (10 142 without arthrodesis; 7 462 with arthrodesis).
- The high surgery rate and consequently the high rate of failed back surgery syndrome contribute to the high direct medical cost of CLBP. Estimations of the global cost due to surgery of CLBP ranged from 19 907 572 € to 81 541 728 € in 2004, according to data sources and computation methods.

4 STANDARD TREATMENTS

4.1 CONSERVATIVE TREATMENT

Non-surgical treatments for Low Back Pain (LBP), a common symptom of the aforementioned pathologies, are numerous. Several of the most common nonsurgical treatments include physical therapy, osteopathic/chiropractic manipulations, NSAIDs, oral steroids, and epidural (cortisone) injection.

Few nonsurgical interventional therapies for low back pain have been shown to be effective in randomized, placebo-controlled trials. Treatments effectiveness has been reviewed recently¹⁰⁻¹⁴, yielding the following recommendations:

- For sciatica or prolapsed lumbar disc with radiculopathy, there is good evidence that chemonucleolysis (treatment of herniated discs with intradiscal injections of a proteolytic enzyme, most commonly chymopapain, an extract from papaya) is moderately superior to placebo injection but inferior to surgery, and fair evidence that epidural steroid injection is moderately effective for short-term (but not long-term) symptom relief¹².
- There is also fair evidence that spinal cord stimulation (a procedure involving the placement of electrodes in the epidural space adjacent to the area of the spine presumed to be the source of pain and applying an electric current in order to achieve sympatholytic and other neuromodulatory effects) is moderately effective for failed back surgery syndrome with persistent radiculopathy, though device-related complications are common¹².
- There is fair to good evidence that prolotherapy (also called sclerotherapy, prolotherapy is a procedure involving the repeated injection of sugar solutions in painful ligaments and tendons that are intended to provoke an inflammatory response and to stimulate production of connective tissue, in order to strengthen these ligaments and tendons, and reduce pain), facet joint injection, intradiscal steroid injection, and percutaneous intradiscal radiofrequency thermocoagulation are not effective¹².
- Insufficient evidence exists to reliably evaluate other interventional therapies¹².

More detailed information on specific treatments can also be found in the KCE report 48¹⁰.

4.2 COMMON SURGICAL APPROACHES

In general, surgery is only considered as a last resort, if attempts at nonsurgical therapies are unsuccessful and if the overall potential benefits of surgery are greater than the potential risks^{11,13}. Surgery may be recommended on an urgent basis if a patient has severe neurological symptoms such as severe weakness or loss of bowel and bladder control.

The main interventions are¹⁵:

- Decompression surgery. This includes laminectomy, laminotomy, foraminotomy. In laminectomy, the lamina is removed and the facet joints are trimmed to create more room for the nerve roots. Laminectomy can be accompanied of fusion, notably when there is a slippage of the vertebrae.
- Spinal fusion. In this procedure, two or more vertebrae are permanently fused together, using a bone graft (either autograft or allograft). Fusion eliminates motion between vertebrae and prevents the slippage or curvature of the spine from worsening after surgery, which would cause more back and/or leg pain. The surgeon may use screws and rods to hold the spine in place while the bones fuse together. The use of rods and screws makes the fusion of the bones happen faster and speeds postoperative rehabilitation.
- Intervertebral disk replacement. In case of degenerative disc disease, a prosthetic disc can be used to restore disc height, hereby maintaining or restoring spinal mobility and avoiding adjacent joint degeneration. This technique has been reviewed in the KCE report 39B16.
- A discectomy (or microdiscectomy) is a surgical procedure in which the central portion of an intervertebral disc, the nucleus pulposus, which is causing pain by stressing the dural sac and/or radiating nerves, is removed.

Effectiveness

The evidence has been recently reviewed^{10,11,17-19}, yielding the following recommendations:

- For non radicular low back pain with common degenerative changes, there is fair evidence that fusion is no better than intensive rehabilitation with a cognitive-behavioural emphasis for improvement in pain or function, but slightly to moderately superior to standard (non intensive) nonsurgical therapy^{11,17}. Less than half of patients experience optimal outcomes (defined as no more than sporadic pain, slight restriction of function, and occasional analgesics) following fusion. Clinical benefits of instrumented versus non-instrumented fusion are unclear¹⁷.
- For radiculopathy with herniated lumbar disc, there is good evidence that standard open discectomy and microdiscectomy are moderately superior to nonsurgical therapy for improvement in pain and function through 2 to 3 months¹⁷.
- For symptomatic spinal stenosis with or without degenerative spondylolisthesis, there is good evidence that decompressive surgery (laminectomy) with fusion (in case of associated spondylolisthesis) or without fusion (in the absence of spondylolisthesis), is moderately superior to nonsurgical therapy through 1 to 2 years. For both conditions, patients on average experience improvement either with or without surgery, and benefits associated with surgery decrease with long-term follow-up in some trials¹⁷.
- Although there is fair evidence that artificial disc replacement is similarly effective compared to fusion for single level degenerative disc disease, insufficient evidence exists to judge long-term benefits or harms¹⁷. There is no evidence that artificial disc replacement is as effective as intensive rehabilitation programs.

- There is limited evidence that in patients with severe CLBP and degenerative changes at L4-L5 or L5-S1 level, who have failed to improve with conservative treatment, surgery is successful in relation to improvements in functional disability (Oswestry) and pain up to 2 years after treatment when compared to traditional non-specific conservative treatment in Sweden (level C)¹¹.

One problem raised in evaluating effectiveness of surgery for degenerative lumbar diseases is the lack of diagnostic specificity²⁰. In practice, specific diagnostic indications for surgery are poorly defined and, with the exception of spondylolisthesis (and lumbar disc prolapse), remaining diagnostic entities are often broadly grouped into categories such as CLBP, degenerative disc disease, discogenic pain, or revision surgery. This lack of diagnostic specificity markedly limits the ability to accurately determine either relative benefit of surgery versus medical management or the optimal surgical procedure for a given clinical scenario²⁰. For instance, the relevancy of fusion for symptomatic degenerative lumbar spine conditions is still debated, but a greater improvement could be expected in patients suffering from an established indication such as spondylolisthesis or degenerative disc disease in comparison to cases of CLBP²¹.

Despite the paucity of studies addressing surgery effectiveness on specific indications, the NASS edited recently recommendations (Table 4.1; Table 4.2) for surgery in cases of spondylolisthesis²² and lumbar spinal stenosis²³. It is noteworthy that none of the recommendations are graded A. There is still insufficient evidence on the effectiveness of surgery on clinical outcomes to draw any firm conclusions¹⁸.

Table 4.1. Main recommendations of the NASS for surgery in spondylolisthesis

Spondylolisthesis	Grade
1. Medical/interventional treatment for degenerative lumbar spondylolisthesis when the radicular symptoms of stenosis predominate, most logically should be similar to treatment for symptomatic degenerative lumbar spinal stenosis.	See Table 4.2
2. Surgery is recommended for treatment of patients with symptomatic spinal stenosis associated with low grade degenerative spondylolisthesis whose symptoms have been recalcitrant to a trial of medical/interventional treatment (12 to 24 weeks).	B
3. Surgical decompression with fusion is recommended for the treatment of patients with symptomatic spinal stenosis and degenerative lumbar spondylolisthesis to improve clinical outcomes compared with decompression alone.	B
4. The addition of instrumentation is recommended to improve fusion rates in patients with symptomatic spinal stenosis and degenerative lumbar spondylolisthesis. However, there is no evidence of clinical benefit.	B
5. Decompression and fusion is recommended as a means to provide satisfactory <u>long-term</u> (≥4 years) results for the treatment of patients with symptomatic spinal stenosis and degenerative lumbar spondylolisthesis	C

A: Good evidence (Level I Studies with consistent finding) for or against recommending intervention.

B: Fair evidence (Level II or III Studies with consistent findings) for or against recommending intervention.

C: Poor quality evidence (Level IV or V Studies) for or against recommending intervention.

I: Insufficient or conflicting evidence not allowing a recommendation for or against intervention.

No: No evidence

Table 4.2. Recommendations of the NASS for surgery in lumbar spinal stenosis

Lumbar spinal stenosis	Grade
1. In patients with severe symptoms of lumbar spinal stenosis, decompressive surgery alone is effective approximately 80% of the time and medical/interventional treatment alone is effective about 33% of the time.	C
2. In patients with moderate to severe symptoms of lumbar spinal stenosis, surgery is more effective than medical/interventional treatment.	C
3. In patients with mild to moderate symptoms of lumbar spinal stenosis, medical/interventional treatment is effective approximately 70% of the time.	C
4. In patients with mild to moderate symptoms of lumbar spinal stenosis, placement of an interspinous process spacing device is more effective than medical/interventional treatment at two-year follow-up.	I
5. At long-term follow-up (8-10 years), surgical decompression in the treatment of lumbar spinal stenosis is consistently supported when compared to medical/interventional treatments.	B
6. In patients with lumbar spinal stenosis and spondylolisthesis, decompression with fusion results in better outcomes than decompression alone.	B
7. Of patients with lumbar spinal stenosis meeting Posner's criteria of instability, decompression with fusion provides better outcomes than decompression alone at greater than two-year follow-up.	I
8. Of patients with lumbar spinal stenosis without spondylolisthesis or instability, there is no evidence to support the addition of a fusion.	I

A: Good evidence (Level I Studies with consistent finding) for or against recommending intervention.

B: Fair evidence (Level II or III Studies with consistent findings) for or against recommending intervention.

C: Poor quality evidence (Level IV or V Studies) for or against recommending intervention.

I: Insufficient or conflicting evidence not allowing a recommendation for or against intervention.

Regarding surgery for lumbar disc prolapse, a recent Cochrane review yielded the following conclusions²⁴:

- Discectomy for carefully selected patients with sciatica due to lumbar disc prolapse provides faster relief from the acute attack than conservative management, although any positive or negative effects on the lifetime natural history of the underlying disc disease are still unclear.
- Microdiscectomy gives broadly comparable results to open discectomy.
- The evidence on other minimally invasive techniques remains unclear (with the exception of chemonucleolysis using chymopapain, which is no longer widely available).

Safety

The complication rate after surgery has been reported to be around 17-18% (6 to 31% depending on technique) with a 6-22% re-intervention rate¹¹. Fusion, with its risk of non union or hardware failure, seems particularly complicated. In a Swedish study, the risk of reintervention went from 6% (non instrumented fusion) to 22%²⁵. Figures were similar in the USA (12% to 14% within 4 years)²⁶. In another study in the USA²⁷, Martin et al. demonstrated that patients with spondylolisthesis had a lower cumulative incidence of reoperation after fusion surgery than after decompression alone, but the rate in the former was still 17.1% (vs 28.0% in the latter). For other diagnoses combined, the cumulative incidence of reoperation was higher following fusion than following decompression alone (21.5% vs. 18.8%, $p = 0.008$). After fusion surgery, 62.5% of reoperations were associated with a diagnosis suggesting device complication or pseudarthrosis²⁷.

Moreover, infection, bleeding, dural leak, nerve root damage and all the possible general anaesthetic risks (e.g. blood clots, pulmonary emboli, pneumonia, heart attack or stroke) may be encountered and exacerbated in patients with risk factors such as elderly patients with hypertension and/or diabetes mellitus, and calcified atherosclerosis of the abdominal aorta and/or common iliac arteries²⁸. Lastly, after a fusion procedure, degeneration of the spinal segment adjacent to the fusion is possible²⁹. The most common abnormal finding at the adjacent segment is disc degeneration. Biomechanical changes consisting of increased intradiscal pressure, increased facet loading, and increased mobility occur after fusion and have been implicated in causing adjacent segment disease. Progressive spinal degeneration with age is also thought to be a major contributor³⁰. A literature review stated that the incidence of symptomatic adjacent segment disease ranged from 5.2 to 18.5% during 44.8 to 164 months of follow-up observation³⁰.

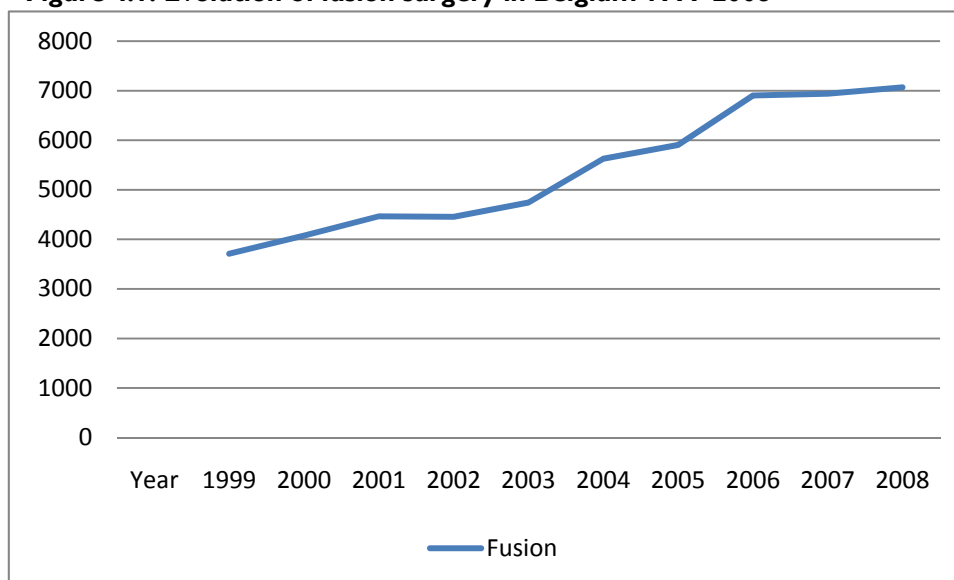
For laminectomy, complications are less frequent when a spinal versus a general anaesthesia is used³¹ and minimally invasive decompression strategies seem consistently to result in short hospital lengths of stay, minimal requirements for narcotic pain medications, and a low rate of readmission and complications³².

Of note, Failed Back Surgery Syndrome was the primary cause of 10.5% of classic hospitalization for CLBP in Belgium in 2004¹⁰.

Frequency of fusion

Given the poor evidence supporting the benefit of the fusion and the existing evidence regarding its complications, it is striking to note a sharp increase in the frequency of such intervention since the nineties²⁷. For instance, there was a 220% increase in the rate of lumbar spine fusion surgery from 1990 to 2001 in the USA³³. In Belgium, in 2004, 5 384 fusions were performed¹⁰, while this number amounts to more than 7 000 interventions in 2008 (Figure 4.1.). Such expansion cannot be explained by scientifically validated indications. Fusion would be indicated in case of spinal instability but instability is a concept lacking a precise clinical and instrumental definition³⁴.

Figure 4.1. Evolution of fusion surgery in Belgium 1999-2008



Source: INAMI/RIZIV, September 2009

Note. The numbers presented do not include arthrodesis performed concurrently to treatment of disk hernia

Added value of new implants

In that context of a questionable risk-benefit balance of classic surgery, posterior dynamic stabilization devices were developed with the aim of allowing a minimally invasive surgery (interspinous implants) or limiting the adverse consequences of arthrodesis on adjacent articulations (pedicle screws). However, their place in the existing recommendations for lumbar surgery is not yet defined. The present report will assess if available scientific evidence point towards the necessity of updating current guidelines.

Key points

- **Few nonsurgical interventional therapies for low back pain have been shown to be effective in randomized, placebo-controlled trials.**
- **The evidence supporting the benefit of surgery in treating degenerative changes of the lumbar spine is limited.**
- **Surgery, and particularly fusion, can generate complications in up to 20% of the cases.**
- **Despite the questionable risk-benefit balance of classic surgery, a significant increase of fusion surgery has been registered in recent years in Belgium (more than 7 000 fusions being performed yearly in 2007).**

5 POSTERIOR NON-FUSION DYNAMIC STABILIZATION DEVICES

5.1 INTRODUCTION

Posterior dynamic stabilization devices are all intended to stabilize the spine in a position close to the normal physiological loading and with the purpose to maintain a controlled movement while sharing the biomechanical load. These devices are presented by the developer as an alternative to decompression surgery or fusion surgery with/without decompression for the treatment of degenerative conditions of the spine that have failed to respond to conservative treatment³⁵. PDS devices fall within two broad categories of design: posterior interspinous devices and pedicle based dynamic rod devices, also labelled pedicle screws.

5.2 NON-FUSION INTERSPINOUS SPACER DEVICES

The posterior interspinous devices were designed as a treatment for neurogenic claudication and the pain attributed to facet joint disease. Interspinous implants act to distract the spinous processes and restrict extension, having the effect of reducing the posterior anulus pressures and theoretically enlarging the neural foramen⁴. The devices are intended to be implanted without a laminectomy and function through indirect decompression, thus avoiding the risk of epidural scarring and cerebrospinal fluid leakage¹.

The interspinous spacer devices can be categorized by design as static or dynamic^{2,36}. Static devices, such as the X STOP, ExtenSure, and Wallis implants, are noncompressible spacers. Their aim is to maintain a constant degree of distraction between the spinous processes. With movements of the lumbar spine, the degree of distraction varies with flexion and extension. Dynamic devices, such as the Coflex and the DIAM, are axially compressible spacers and allow the degree of distraction to alter with flexion.

In Belgium, a lot of interspinous devices are currently in use (X STOP, Wallis, DIAM, ExtenSure, Coflex, Aperius PercLID, InSwing, InSpace, BacJac). Only one device (the X STOP, Kyphon, Inc., Sunnyvale, CA; Medtronic, Memphis, TN) is approved by the FDA, although others are currently under investigation for approval, including the Interspinous "U" (Coflex; Paradigm Spine, New York, NY), the DIAM Spine Stabilization System (Medtronic Sofamor Danek, Memphis, TN) and Wallis System (Zimmer Spine, Minneapolis, MN). Our study will only focus on these four latter devices.

5.2.1 The X STOP Device

The X STOP (eXtension STOP) consists of an oval titanium spacer that is positioned between the two symptomatic spinous processes. The lateral wing is then attached to prevent the implant from migrating anteriorly or laterally out of position⁴. The X STOP Interspinous Process Distraction System (St. Francis Medical Technologies, Inc.) was approved for marketing in Europe and Japan in 2001, and by the US Food and Drug Administration (FDA) in November 2005. St. Francis Medical Technologies was subsequently acquired by Kyphon, Inc. (Sunnyvale, CA), and Kyphon was acquired by Medtronic, Inc., (Minneapolis, MN), in November 2007. X STOP is now a Medtronic product.

Medtronic has launched the polyetheretherketone (PEEK) version, the second generation of the X STOP system. The PEEK polymer, a biomaterial widely accepted for spinal applications, provides several benefits such as biocompatibility and radiolucency (allows the passage of X-rays). In the new system, the body of the device that is implanted between the spinous processes to prevent the pinching of the nerves is composed of a PEEK outer ring, with the remainder of the device made of titanium alloy (the original product is made completely of titanium alloy). The X STOP PK implant has been designed to be more elliptical than the first generation X STOP device.

The X STOP PK system has been in clinical use in Europe since 2004. The FDA approved the X STOP PK system in August 2006.



"Images © Medtronic, Inc. Used by permission only."

According to the FDA approval order, the X STOP is indicated for treatment of patients aged 50 or older suffering from neurogenic intermittent claudication secondary to a confirmed diagnosis of lumbar spinal stenosis (with X-Ray, MRI and/or CT evidence of thickened ligamentum flavum, narrowed lateral recess and/or central canal narrowing). The X STOP is indicated for those patients with moderately impaired physical function who experience relief in flexion from their symptoms of leg/buttock/groin pain, with or without back pain, and have undergone a regimen of at least 6 months of non operative treatment. The X STOP may be implanted at one or two lumbar levels in patients in whom operative treatment is indicated at no more than two levels. The device is being marketed as a minimally invasive alternative to laminectomy.

Under general or local anaesthesia the patient is positioned with the spine flexed, and the operative level(s) confirmed by X-rays. A midline incision is made over the appropriate spinal levels and deepened to display the spinous processes and their intact joining (interspinous) ligament. The blocking device is sized and positioned in this space between the flexed spinous processes, thus preventing extension during normal activities. The implant is not rigidly attached to the osseous anatomy but is restricted from migrating backward by the supraspinous ligament, forward by the lamina, cranially and caudally by the spinous processes, and laterally by the device's wings on each side¹.

The device is contraindicated in patients with: an allergy to titanium or titanium alloy; spinal anatomy or disease that would prevent implantation of the device or cause the device to be unstable in situ, such as: significant instability of the lumbar spine, e.g. isthmic spondylolisthesis or degenerative spondylolisthesis greater than grade 1.0 (on a scale from 1 to 4), an ankylosed segment at the affected level(s), acute fracture of the spinous process or pars interarticularis and significant scoliosis (Cobb angle greater than 25 degrees); cauda equina syndrome defined as neural compression causing neurogenic bowel or bladder dysfunction; diagnosis of severe osteoporosis; and active systemic infection or infection localized to the site of implantation (Medtronic, 2008).

The X STOP system is the only interspinous process decompression system to have received FDA approval^a.

^a According to Bono and Vaccaro (2007)², the FDA granted approval for ExtenSure bone allograft interspinous spacer device. However, this affirmation was rebutted by the FDA and NuVasive (personal communication). The FDA Approval was granted for ExtenSure CoRoent which is a vertebral disk replacement.

5.2.2 The Wallis

Wallis (WALL Inter Spinous placed) was invented in 1984 by Dr. Jacques Senegas. Wallis is presented as a lumbar dynamic stabilization device designed to restore the natural biomechanical function of the spine. It would control the mobility in flexion and extension while preserving the spine anatomy.

Wallis (Abbott Spine) was introduced in Europe in 1986. It is not currently FDA approved for use in the United States. The device's original design was a titanium block inserted between adjacent processes and held in place with a flat Dacron cord or ribbon wrapped around the spinous process above and below the block. The second generation Wallis implant (Zimmer Spine) is an interspinous blocker, which is made of PEEK (polyetheretherketone). Due to its shape and the properties of PEEK, the implant has much greater elasticity (30 times less rigid than titanium) than the first generation³⁷. In addition, the implant includes two ligaments made of woven Dacron that are wrapped around the spinous processes and fixed under tension to the blocker. Wallis is fixed to the spine by two polyester bands looped around the proximal and distal spinous processes of the instrumented level and reattached to the spacer by means of two clips that are visible on plain radiographs³⁷.

The procedure to insert the Wallis implant is typically associated with minimally invasive unilateral decompression, consisting in discectomy, undercutting to enlarge the spinal canal, or both³⁸. The intervention is performed under general anaesthesia.



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According to Senegas (2002)³⁹, the inventor of Wallis, the Wallis system can be used in the following indications:

- Discectomy for voluminous herniated disc leading to substantial loss of disc material
- A second discectomy for recurrence of herniated disc
- Discectomy for herniation of a transitional disc with sacralization of L5
- Degenerative disc disease at a level adjacent to a previous fusion
- Isolated Modic I lesion leading to chronic low-back pain^b

The Wallis system is only applicable above L5 and does not include L5-S1³⁸.

Contra-indications include³⁸: Grade V degenerative lesions; spondylolisthesis, osteoporosis; non-specific LBP; patent constitutional or acquired spinous process insufficiency; L5-S1; litigation, patent psychological disorders.

^b Signal changes on MRI in the vertebral body marrow adjacent to the end plates are known as Modic changes (MC). MCs are divided into three different types. Type 1 consists of fibro vascular tissue, type 2 is yellow fat, and type 3 is sclerotic bone⁴⁰.

5.2.3 The DIAM System

The DIAM (Device for Intervertebral Assisted Motion) Spinal Stabilization System (Medtronic Sofamor Danek, Memphis, TN) is a soft interspinous spacer developed by Dr. Jean Taylor in 1997. The core is made of silicone, which is covered by a polyethylene coating. The device is secured in place with two laces around above and below adjacent spinous processes. DIAM is designed to dynamically support the vertebrae while also maintaining distraction of the foramina. The manufacturer's proposed indications are degenerative spinal stenosis. According to the developer of this implant⁴¹, three indications can be proposed: discogenic disease, either primary or recurrent, with or without discectomy; posterior disease resulting in central stenosis, foraminal stenosis, facet disease, or ligamentous instability leading to no more than a Grade I spondylolisthesis; and, to protect from junction disease by implanting a DIAM above a fresh or existing lumbar fusion. The relative efficacy of the device in these various diseases was not analyzed⁴¹.



Available at <http://www.spinalstenosis.org/diam.php> (June 2009)

5.2.4 The Coflex

The Coflex (previously known as the Fixano U or Interspinous U) (Paradigm Spine) was developed by Dr. Jacques Samani in 1994. Coflex (Co-promotes flexion) is used in Europe but is not currently FDA approved. Coflex is a titanium device with a U-shaped body and two wings on each side. Coflex is designed to permit flexion of the lumbar spine and to restrict mobility in extension and rotation. Coflex can be applied from L1 to L5 (sometimes S1). Theoretically, it can be utilized in any case in which extension aggravates the neurogenic pain. Coflex is designed for patients who failed conservative treatment but who are not candidate for a complete laminectomy or an irreversible procedure such as fusion. According the manufacturer⁴², the main indication for this device is radiographically confirmed moderate to severe stenosis with neural element compromise resulting in claudication and/or radicular symptoms isolated to 1 or 2 levels, in the region of L1 to L5 with or without concomitant low back pain, including conditions such as stable grade I spondylolisthesis. An extended indication is stabilization above or below a fusion ("topping-off") in the same procedure to minimize adjacent level degeneration. Contraindications of Coflex include severe segmental instability, progressive degenerative spondylolisthesis (grade 2 or higher), kyphosis, severe scoliosis (greater than 25 degrees), isthmic spondylolisthesis, and significant osteopenia (Product Information from Paradigm Spine).



Available at: <http://www.spine-health.com/treatment/spinal-fusion/interspinous-process-spacers> (June 2009)

The table 5.1. clearly demonstrates that for each device indications are numerous and overlap. There is an obvious need to standardize such indications for proper evaluation and rational clinical utilization².

Table 5.1. Classification of interspinous devices

Name of the device	FDA approval	CE mark	Indications according the manufacturer	Contra-indications according the manufacturer
X STOP St. Francis Medical Technologies, Inc.	2005	2001	mild lumbar spinal stenosis and neurogenic claudication	allergy to titanium or titanium alloy; significant instability of the lumbar spine; cauda equina syndrome; severe osteoporosis; active systemic infection or infection localized to the site of implantation
DIAM Medtronic Sofamor Danek	No but currently in an investigational US FDA approved study.	Yes	degenerative spinal stenosis	
Wallis Zimmer Spine	No	Yes	voluminous herniated disc ; recurrence of herniated disc; degenerative disc disease at a level adjacent to a previous fusion; Modic I lesion leading to chronic low-back pain	grade V degenerative lesions; spondylolisthesis; osteoporosis; non-specific LBP; patent constitutional or acquired spinous process insufficiency; L5-S1; litigation; patent psychological disorders
Coflex Paradigm Spine	No but currently in a US FDA-approved study	Yes	patients with moderate to severe lumbar spinal stenosis with concomitant low back pain and neurogenic claudication	severe segmental instability; progressive degenerative spondylolisthesis; kyphosis; severe scoliosis; isthmic spondylolisthesis; significant osteopenia

5.3 NON-FUSION PEDICLE SCREWS

The second major type of lumbar non-fusion posterior stabilization device has some similarities to standard rigid fusion devices through the use of pedicle screw systems.

Pedicle-based dynamic devices were first designed to stabilize the abnormal segment and to unload degenerated discs and facet joints, while maintaining intersegmental motion. By unloading the pressure on the degenerated disc and facets, pedicle-based dynamic devices have the potential to reduce pain associated with these anatomical structures. Theoretically, they can be used to prevent adjacent-segment disease, either by replacing the whole construct with dynamic rods or by “topping off” the rigid instrumented segment with pedicle-based dynamic devices, avoiding an abrupt change from a rigid construct to the more mobile adjacent segment³⁴. These devices can be used to stabilize posterior iatrogenic destabilizing surgery, such as wide laminectomy and facetectomy¹.

Ideally, these devices would be implanted with minimal damage to the muscular and ligamentous structures that participate in normal spinal motion. However, currently, surgical implantation of dynamic stabilization devices remains very invasive, with resulting disruption of the muscle and ligamentous structures³⁴.

Diverse pedicle screws systems are used in the international market (Graf ligament, Dynesys, Isobar, DSSS, M-brace, TFAS and TOPS). The main pedicle screw system used in Belgium is the Dynamic neutralisation system (Dynesys Spinal System).

5.3.1 The Dynesys Dynamic Stabilization System

The Dynesys system was invented by Drs. Gilles Dubois and Otmar Schwarzenbach. The system consists of titanium alloy screws, polyester cords, and spacers between screw heads. The stabilising cord connects the pedicle screw heads through a hollow core in the spacers and holds these in place.

This system is implanted and tensioned to provide spinal support such that the cord provides support and limits flexion, while the spacer limits extension. Thus, the Dynesys is designed to restabilize spinal segments that show symptoms of stenosis or spondylolisthesis. When used without bone graft, it is designed to preserve the natural function of the spine by allowing motion and sharing in-load transmission⁴³.



“Images © Zimmer, Inc. Used by permission only.”

The most frequently operated segment is at L4/L5. Postoperative bracing is applied only in exceptional circumstances⁴⁴.

Since Dynesys fulfils the requirements of the EU Guidelines (93/42 EEC), it was awarded a CE label in Europe in 1998. The Dynesys Spinal System was cleared by the US Food and Drug Administration (FDA) via a 510(k) clearance in March 2004. The product’s label indicates Dynesys is intended to provide immobilization and stabilization of spinal segments in skeletally mature patients as an adjunct to fusion in the treatment of the following acute and chronic instabilities or deformities of the thoracic, lumbar, and

sacral spine: degenerative spondylolisthesis with objective evidence of neurologic impairment, and failed previous fusion (pseudarthrosis). In addition, when used as a pedicle screw fixation system, the Dynesys Spinal System is indicated for use in patients:

- Who are receiving fusions with autogenous graft only;
- Who are having the device fixed or attached to the lumbar or sacral spine;
- Who are having the device removed after the development of a solid fusion mass.

It is not specifically indicated for lumbar stenosis.

These clinical indications are somewhat surprising since Dynesys was created to dynamically stabilize the lumbar spine, without fusion of the vertebrae. According to the manufacturer (Zimmer Spine, May 2009), Dynesys is indicated for the lumbar segments from L1 to L5 and L5-S1 in the following pathologies:

- Massive or Recurrence of disc herniation
- Central disc herniation
- DDD with Mechanical Back Pain up to Modic I
- Lumbar Canal Stenosis
- Degenerative spondylolisthesis (up to grade I)

At the present time, it is undergoing an IDE study in the United States for a non fusion application (the intended use of the device and the actual use elsewhere in the world).

Key points

- **Posterior dynamic stabilization devices are designed to stabilize the spine in a position close to the normal physiological loading and with the purpose to maintain a controlled movement while sharing the biomechanical load.**
- **These devices are presented as an alternative to decompression surgery or fusion surgery with/without decompression for the treatment of degenerative conditions of the spine that have failed to respond to conservative treatment.**
- **Two classes of dynamic stabilizers, interspinous and pedicle screw-based dynamic systems are currently in use.**
- **The interspinous spacer devices can be designed as static or dynamic. Static devices (X STOP, ExtenSure, Wallis) are non compressible spacers. They aim to maintain a constant degree of distraction between the spinous processes. Dynamic devices (Coflex, DIAM), are compressible spacers and can expand further with flexion.**
- **Because of the anatomic considerations of the S1 spinous process, the interspinous spacer devices are not favourable, nor currently recommended, for use at L5-S1.**
- **Pedicle screw based dynamics systems (Graf ligament, Dynesys, Isobar, DSSS, M-brace, TFAS and TOPS) offload spinal units in a fashion similar to pedicle-based posterior instrumentation.**
- **Four kinds of interspinous spacers (X STOP, Wallis, Coflex and DIAM) and one kind of pedicle screw based system (Dynesys) are mainly used in Belgium.**
- **Though some clinical data exist for some of these devices, defining the indications for these procedures remains crucial and should emerge from well-designed randomized controlled trials.**

6 ASSESSMENT OF CLINICAL OUTCOMES

Investigators measured primary or secondary clinical outcomes by changes in:

- the Zurich Claudication Questionnaire. The questionnaire includes three scales with seven questions on symptom severity, five on physical function, and six on satisfaction. In an original study conducted on measurement properties of this self-administered measure in a lumbar spinal stenosis population⁴⁵, this measure demonstrated its psychometric properties. The test-retest reliability of the scales ranged from 0.82 to 0.96, the internal consistency from 0.64 to 0.92, and the responsiveness^c from 0.96 (symptom severity scale) to 1.07 (physical function scale). The direction, statistical significance, and strength of hypothesized relationships with external criteria were as expected reproducible, internally consistent, valid, and highly responsive. This self-reported outcome assessment can be used to complement generic instruments in outcome assessment of patients with lumbar spinal stenosis⁴⁵.
- the Visual Analogue Scale measuring pain. A VAS consists of a line, usually 100-mm long, with ends labelled as the extremes of pain (e.g. 'no pain' to 'pain as bad as it could be'). Specific points along this line might be labelled with intensity-denoting adjectives or numbers. There is great evidence to support the validity of this instrument, since pain intensity scores as measured by the VAS correlated positively with other self-reported measures of pain intensity^{46,47}. The reliability of VAS scores has also been demonstrated. Finally, VAS is potentially more sensitive to changes in pain intensity than measures with a more limited number of response categories⁴⁶.
- the Oswestry Disability Index (ODI), a valid and vigorous measure of condition-specific disability^{46,48,49}. The ODI has 10 items that refer to activities of daily living that might be disrupted by LBP. The total ODI score ranges from 0 (no disability) to 100 (maximum disability). The ODI was validated and improved in a study by Medical Research Council group and this version (2.0) is now recommended for general use^{46,48,49}. The construct validity of the ODI has been confirmed by correlation with other questionnaires measuring low-back-pain-specific disability⁵⁰. Reproducibility was originally tested by Fairbank, who included patients with chronic low back pain. Davidson and Keating (2002)⁴⁸ also reported that ODI has sufficient reliability to recommend it as a standardized measure of activity limitation.
- the SF-36 or SF-12, general health surveys capturing reliable and valid information about functional health and well-being from the patient point of view. The SF-36 and SF-12 Health Surveys measure the same eight health domains, providing psychometrically-based physical component summary (PCS) and mental component summary (MCS) scores⁵¹.

Questionnaires used to assess these outcomes are presented in Appendix I.

^c Responsiveness refers to the ability to detect clinically important changes in the construct being measured. In this study, the responsiveness of the symptom severity and physical function scales was assessed with the standardized response mean (SRM; mean change/standard deviation of change) and with correlations between changes in scale scores and the satisfaction score.

Moreover, Davidson and Keating (2002)⁴⁸ examined 5 commonly used questionnaires for assessing disability in people with low back pain: the modified Oswestry Disability Questionnaire, the Quebec Back Pain Disability Scale, the Roland-Morris Disability Questionnaire, the Waddell Disability Index, and the physical health scales of 36-Item Short-Form Health Survey (SF-36) in patients undergoing physical therapy for low back pain. Measurements obtained with the modified Oswestry Disability Questionnaire, the SF-36 Physical Functioning scale, and the Quebec Back Pain Disability Scale were the most reliable and had sufficient width scale to reliably detect improvement or worsening in most subjects. The reliability of measurements obtained with the Waddell Disability Index was moderate, but the scale appeared to be insufficient to recommend it for clinical application. The Roland-Morris Disability Questionnaire and the Role Limitations-Physical and Bodily Pain scales of the SF-36 appeared to lack sufficient reliability and scale width for clinical application.

On the other hand, the Zurich Claudication Questionnaire (ZCQ)/Swiss Spinal Stenosis Questionnaire (SSS), Oswestry Disability Index (ODI), Likert Five-Point Pain Scale and 36-Item Short Form Health Survey (SF-36) were evaluated as appropriate measures for assessing treatment of degenerative lumbar spondylolisthesis (Grade of Recommendation: A)⁹.

7 CLINICAL EFFECTIVENESS AND SAFETY

7.1 RESEARCH QUESTIONS

Question 1: Is lumbar non-fusion posterior dynamic stabilization a clinically effective treatment for patients with symptomatic lumbar spinal stenosis, degenerative spondylolisthesis, degenerative disc disease, herniated disc or facet joint osteoarthritis?

Question 2: Is lumbar non-fusion posterior dynamic stabilization a safe procedure for patients with symptomatic lumbar spinal stenosis, degenerative spondylolisthesis, degenerative disc disease, herniated disc or facet joint osteoarthritis?

The selection criteria used in our literature search strategy were formulated according the following PICO:

Selection criteria	Inclusion criteria	Exclusion criteria
Population	People with symptomatic lumbar spinal stenosis, degenerative spondylolisthesis, degenerative disc disease, herniated disc or facet joint osteoarthritis who have failed to respond to conservative management of at least 6 months.	<p>No information on the pre-specified target population</p> <p>Stenosis of cervical spine</p> <p>Patients with vertebral fractures, cancer, trauma, or infection.</p> <p>In vitro investigations (cadaveric spine specimens).</p>
Intervention	<p>Lumbar non-fusion posterior dynamic stabilization devices with/without decompression without fusion</p> <p>Lumbar non-fusion posterior dynamic stabilization devices may be divided into two main groups:</p> <ol style="list-style-type: none"> 1. interspinous spacers 2. pedicle screw systems 	<p>Any of several different surgical techniques of fusion (including instrumented [e.g., using screws, metal and bone cages] or non-instrumented fusion)</p> <p>Lumbar arthroplasty (e.g., Charité Lumbar Disc arthroplasty or Pro-Disc)</p> <p>Disc replacement (e.g., Dynardi)</p>
Comparator	<p>Conservative treatment</p> <p>Decompression (laminectomy or discectomy) or fusion with/without decompression</p>	
Outcome	<p>All clinical outcomes</p> <p>Efficacy:</p> <p>Primary—patient assessed leg and/or back pain, analgesic usage, patient</p>	<p>Imaging outcomes : radiography or MRI as only outcome measure</p>

	<p>assessed QoL, observer assessed functional status</p> <p>Secondary—observer assessed patient pain and quality of life, patient assessed functional status, analgesic usage, hospital length-of-stay, rate of reoperation, device removal</p> <p>Safety:</p> <p>Primary—adverse physical health outcomes, including death, infection, haemorrhage, neurological symptoms (e.g. numbness, tingling, paralysis), myocardial infarction, pulmonary embolism, deep vein thrombosis, infection, allergic reaction to implant, adjacent segment disease</p> <p>Secondary—device failure, device slip, device breakage, screw loosening</p>	
Design	<p>Meta-analysis, randomised or controlled clinical trials, systematic reviews, prospective observational studies, follow-up studies including at least 20 patients.</p> <p>No restriction on language.</p>	<p>All papers which do not include inclusion criteria (comments, letters, historical articles, abstracts, non systematic literature review, conference proceedings, retrospective studies, case reports ...)</p>

7.2 SEARCH STRATEGY

Between April and June 2009, we have undertaken a literature review to identify relevant and published evidence to answer the key clinical questions. An iterative search strategy was performed, first searching for existing health technology assessments (HTA) and systematic reviews, and subsequently for randomized controlled trials (RCTs) published after the most recent good-quality HTA retrieved. A complementary search was done for the additional primary studies published in indexed journals. The common hierarchy of study designs used in reviews of effectiveness (RCTs, quasi experimental studies, cohort studies, case-control studies, cross-sectional studies, before-and-after studies and case series) is based on the degree to which different study designs are inherently susceptible to various biases⁵². Reviewers often focus on randomised studies, but this emphasis may be unwarranted when literature scoping identifies only a few small randomised studies as is the case in the present research. In this situation it may be informative to include observational studies while stratifying the analysis by types of studies included⁵². A particular group of studies have a before-and-after design, where the same participants are evaluated before and after an intervention with no additional comparator or 'control'. The comparison is made within the single group of participants. Here it is often very hard to conclude whether any differences seen can be attributed to the intervention. However, when RCTs are absent, large differences in before-and-after studies may provide some indication of effect⁵².

Finally, the grey literature was researched via Google and Google Scholar and via contacts with suppliers and manufacturers of lumbar non-fusion posterior stabilization devices. Overall, the search was enlarged to reports and articles published between 1980 and 2009. No language restriction was used.

7.2.1 For HTA Reports

The search terms were: low back pain/Title & Abstract OR spine stenosis/Title & Abstract OR spondylolisthesis/Title & Abstract OR lumbar device/Title & Abstract first and then low back pain/All fields.

The search was performed between April and June 2009 in the following databases:

- Health Technology Assessment Database (HTA)
- NHS Economic Evaluation Database (NHS EED)
- Database of Abstracts of Reviews of Effects (DARE)

The websites of the following HTA agencies were also searched:

- AETMIS (Agence d'évaluation des technologies et des modes d'intervention en santé): <http://www.aetmis.gouv.qc.ca/>
- AETNA (American health care benefits company): <http://www.aetna.com/provider/medical/>
- AETS (Agence Européenne des Technologies de Santé) : <http://www.aets-europe.fr/>
- AETSA (Agencia de Evaluacion de Tecnologias Sanitarias de Andalucia): <http://www.juntadeandalucia.es/>
- AHFMR (Alberta Heritage Foundation for Medical research) and IHE (Institute of Health Economics): <http://www.ahfmr.ab.ca/>
- AHRQ (Agency for Healthcare Research and Quality): <http://www.ahrq.gov/>
- ASERNIP Website : <http://www.surgeons.org/Content/NavigationMenu/Research/ASERNIPS/default.htm>
- BCBSA (Blue Cross BlueShield Association): <http://www.bcbs.com/>
- CADTH (Canadian Agency for Drugs and Technologies in Health): <http://cadth.ca/index.php/en/home>
- CAHTA (Catalan Agency for Health Technology Assessment): <http://www.gencat.cat/salut/depsan/units/aatrm/html/en/Du8/index.html>
- California Technology Assessment Forum: <http://www.ctaf.org/>
- CAST (Centre for Applied Health Services Research and Technology Assessment): <http://www.cast.org/>
- CCOHTA (Canadian Coordinating Office for Health Technology Assessment): http://www.ccohta.ca/entry_e.html
- CEDIT (Comité d'Evaluation et de Diffusion des Innovations Technologiques) : <http://cedit.aphp.fr/>
- CIHR (Canadian Institutes for Health Research): <http://www.cihr-irsc.gc.ca/>
- DACEHTA (Danish centre for HTA): http://www.sst.dk/Planlaegning_og_behandling/Medicinsk_teknologivurdering.aspx?lang=en
- ECRI Institute: <http://www.ecri.org/>
- FINOHTA (Finnish Office for Health Technology Assessment): <http://finohta.stakes.fi/EN/index.htm>
- Hayes: <http://www.hayesinc.com/>
- HSTAT-NLM: <http://www.ncbi.nlm.nih.gov/books/bv.fcgi?rid=hstat>

- HTAi (Health Technology Assessment international): <http://www.htai.org/>
- ICES (Institute for Clinical Evaluative Sciences): <http://www.ices.on.ca/>
- ICSI (Institute for Clinical Systems Improvement): <http://www.icsi.org/>
- INAHTA (International Network of Agencies for Health Technology Assessment): <http://www.inahta.org/>
- IQWiG (Institut für Qualität und Wirtschaftlichkeit im Gesundheitswesen): <http://www.iqwig.de/>
- Monash Institute of Health Services Research: <http://www.mihsr.monash.org/>
- MSAC (Medical Services Advisory Committee): <http://www.msac.gov.au/>
- Minnesota Department of Health: <http://www.med.monash.edu.au/healthservices/cce/>
- NCC HTA: <http://www.nchta.org/>
- NHS (National Institute for Health research HTA): <http://www.show.scot.nhs.uk/> and HTBS <http://www.htbs.org.uk/board.htm>
- NICE (National Institute for Health and Clinical Excellence): <http://www.nice.org.uk/>
- North American Spine Society: <http://www.spine.org/Pages/Default.aspx>
- NZHTA (New Zealand Health Technology Assessment): <http://nzhta.chmeds.ac.nz/>
- OHPPR (Oregon Health Plan Policy and Research): http://www.ohppr.state.or.us/hrc/welcome_hrcreport.htm
- RAND Corporation: <http://www.rand.org/>
- SBU (The Swedish Council on Technology Assessment in Health Care): <http://www.sbu.se/en/>
- SNHTA (Swiss Network on HTA): <http://www.snhta.ch/home/portal.php>
- VATAP (US Department of veteran Affairs): <http://www.va.gov/>

7.2.2 For systematic reviews

The following databases were searched:

- Cochrane Reviews database
- Centre for Reviews and Dissemination (CRD) databases (University of York, UK) including DARE (Database of Abstracts of Reviews of Effects), NHS EED (NHS Economic Evaluation Database) and HTA (Health Technology Assessment) databases

7.2.3 For Controlled Trials

The following search strategy was used:

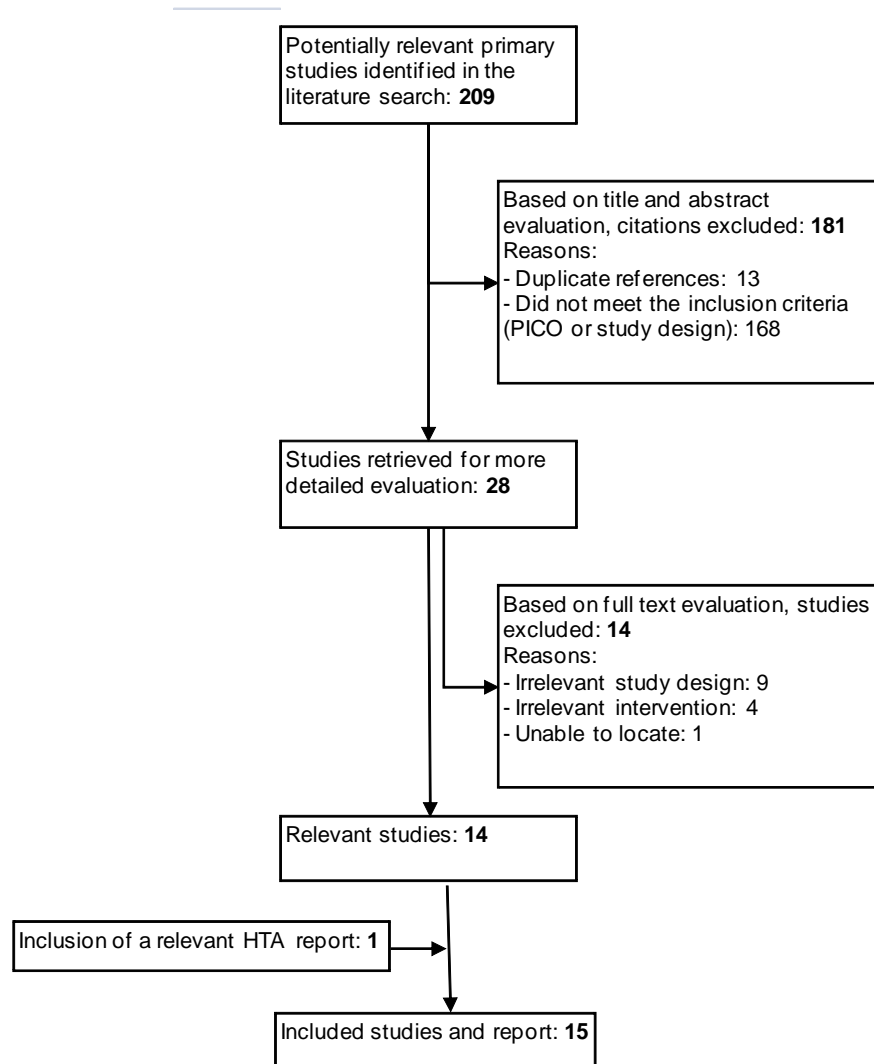
Date	April 7th 2009
Database (name + access ; eg Medline OVID)	Cochrane Central Register of Controlled Trials
Date covered (segment)	-
Search Strategy (attention, for PubMed, check « Details »)	"dynamic stabilization in Title, Abstract or Keywords and spinal stenosis in Title, Abstract or Keywords "interspinous device in Title, Abstract or Keywords and spinal stenosis in Title, Abstract or Keywords "interspinous spacer in Title, Abstract or Keywords and spinal stenosis in Title, Abstract or Keywords "pedicle screw in Title, Abstract or Keywords and spinal stenosis in Title, Abstract or Keywords "X Stop in Title, Abstract or Keywords and spinal stenosis in Title, Abstract or Keywords "Wallis in Title, Abstract or Keywords and spinal stenosis in Title, Abstract or Keywords "DIAM in Title, Abstract or Keywords and spinal stenosis in Title, Abstract or Keywords "Coflex in Title, Abstract or Keywords and spinal stenosis in Title, Abstract or Keywords "Dynesys in Title, Abstract or Keywords and spinal stenosis in Title, Abstract or Keywords
Note	13 references

An additional search has been done for studies in progress on the site <http://ClinicalTrials.gov>. The terms "Wallis OR DIAM OR X-Stop OR XStop OR dynesys OR coflex AND lumbar OR spinal OR back pain OR spondylolisthesis OR vertebral" have been used.

7.2.4 For additional publications

The search strategy for meta-analyses, systematic reviews and additional primary studies, developed by one researcher (SS), is described in Appendix 2 (database, Mesh and/or "free terms"). All reference citations from all literature sources were collated into an Endnote 8.0 database. Duplicate references were removed. Two reviewers (SS and SG) independently assessed titles and abstracts of identified references for inclusion according to pre-set criteria. All potentially relevant papers were retrieved in full and were further assessed by the same 2 independent reviewers. Discrepancies between reviewers were solved by consensus. In addition, the reference lists of the selected articles were also searched and the additional references retrieved were assessed through the same procedure. This in-depth screening of full-text papers resulted in a total of 15 accepted studies (Figure 7.1). The list of excluded studies after in-depth screening is presented in Appendix 3.

Figure 7.1. Literature search results flow chart



7.3 QUALITY APPRAISAL

The quality of the selected papers was assessed by one reviewer (SS) on the basis of the full-text. To assess the quality of HTA reports, the INAHTA checklist was used (www.inahta.org) (Appendix 4). Cochrane systematic review was not appraised according to its high quality of evidence. The quality of RCTs and prospective observational studies was assessed using the checklists of the Dutch Cochrane Centre (www.cochrane.nl) (Appendix 4). However, none of this source proposed an evaluation grid for before-and-after study. Therefore, we followed the criteria proposed by NHS Centre for Reviews and Dissemination⁵².

Quality assessment was summarized as good, average or poor quality (according to the quality of evidence grading for interventional procedures of ASERNIP, http://www.surgeons.org/Content/NavigationMenu/Research/ASERNIPS/ASERNIPsReviewProcess/Classifications_Syst.htm). This classification was chosen because it specifically focuses on new surgical procedures. High-quality evidence is defined here as having a low risk of bias and no other significant flaws. HTA reports received a poor quality appraisal when the search of the literature was insufficient and no quality assessment of included studies was reported. Two major criteria were considered for the quality assessment of the RCTs: the randomization process and the blinding of the assessors. A RCT received a poor quality appraisal when at least one of these two criteria was negative. Poor quality studies were excluded from further review.

7.4 SEARCH RESULTS

7.4.1 Results for non-fusion interspinous devices

7.4.1.1 HTA reports and systematic reviews

Four potential HTA reports were identified. Only one of these – the MSAC 2007 report – was considered a good quality report and is presented here³⁵. The quality appraisal of the four identified HTA reports and the evidence table of the included HTA report are provided in Appendix 4 and 5.

One Cochrane systematic review¹⁸ was identified that assessed surgery for degenerative lumbar spondylosis.

Medical Services Advisory Committee HTA Report (Australia, 2007)

This HTA report aimed to evaluate the safety, effectiveness, and cost considerations associated with lumbar non-fusion posterior stabilization devices. The clinical part of this report focused on two devices: X STOP and Wallis. Other devices (Coflex and DIAM) were not deeply reviewed because of limited data on clinical outcomes in the literature (only abstracts were retrieved).

The literature search conducted up until April 2006 retrieved one randomized control trial (Zucherman et al. 2005⁵³; n=100) and one uncontrolled before-and-after case series (Lee et al. 2004⁵⁴; n=10) conducted with X STOP device and one prospective cohort study (Senegas 2002³⁹; n=80) with the Wallis system. The two first studies assessed the effectiveness and safety of the X STOP in patients with neurogenic claudication secondary to lumbar spinal stenosis, while the third assessed the efficacy and safety of Wallis in patients with recurrent herniated disc(s).

The randomised controlled trial by Zucherman et al. (2004; 2005)⁵³ involved 191 patients at 9 investigational sites, with 100 patients assigned to undergo X STOP implantation and 91 allocated to a non-operative control treatment which included the use of bed rest, controlled physical activity, physiotherapy, lumbar corset, non-steroidal anti-inflammatory drugs, analgesics and a variable number of epidural steroids. The inclusion criteria included age greater than or equal to 50 years with leg, buttock or groin pain relieved by flexion who had failed at least six months of non-operative therapy. Patients had to be able to sit for 50 minutes without pain and walk at least 50 feet. Lumbar spinal stenosis was documented by CT or MRI at one or two levels. Patients were excluded if they had a fixed motor deficit, cauda equina syndrome, significant lumbar instability, prior lumbar surgery, significant peripheral neuropathy, greater than 25° of scoliosis, more than grade I spondylolisthesis at the affected level, severe osteoporosis, pathologic fractures, Paget's disease, recent steroid use, obesity, active infection or systemic disease.

In the X STOP arm, 64 patients received one implant and the remaining 36 received two implants. The most common levels were L4/L5 (65%) and L3/L4 (32%). The procedure was performed under local anaesthesia for 97 out of 100 patients. Most patients (96/100) went home in less than 24 hours. There was significantly more loss to follow-up in the non-operative group at each time point. At the six-week evaluation, 6% of the X STOP group and 28% of the non-operative group did not complete the questionnaire assessments. At the one-year evaluation, 12% of the X STOP group and 32% of the non-operative group had incomplete data. The primary reasons for incomplete data were laminectomy (10%) and withdrawal from the study (7.5%). Two patients in each group died during the first year of follow-up and two patients had their implant removed. Three patients in the X STOP group and 17 patients in the non-operative group had laminectomy. An additional three patients in the X STOP group and 12 patients in the non-operative group withdrew from the study. Patients who had the implant removed, went on to laminectomy or withdrew from the study were considered treatment failures.

At the completion of the study, data from 93 patients from the X STOP group and 81 patients from the control group were analysed (7 X STOP patients and 10 control patients were lost to follow up). Over a 2 year follow-up period, Zucherman et al. recorded the following results: 60.2% (56/93) of patients in the X STOP group indicated an improvement in symptom severity, compared with 18.5% (15/81) of patients in the control group ($p < 0.001$); 57.0% of the X STOP group (53/93) recorded an improvement in physical function, compared with 14.8% of the control group (12/81) ($p < 0.001$) and 73.1% (68/93) of the X STOP group were somewhat satisfied with their treatment, compared with 35.9% of control patients (28/78) ($p < 0.001$). However, more patients reported improvement at 12 months than at 24 months. Consequently, in this study, a percentage of patients whose symptoms improved at 6 and 12 months showed a trend of regression of pain and physical function symptoms toward baseline levels.

Six patients in the X STOP group and 24 patients in the control group underwent decompressive surgery (laminectomy) for unresolved stenosis symptoms during the 2 year follow up period – while the need for surgery rate was higher in the control group compared to X STOP group the fact that 6/93 (6.5%) X STOP patients required laminectomy is substantial. Major complications occurred in up to 3% of patients, although one death was caused by pulmonary oedema in a patient with a history of cardiovascular disease. Minor complications such as respiratory distress, wound swelling and pain occurred in up to 8% of patients⁵³.

This randomised controlled trial was conducted by James Zucherman and Ken Hsu, both are inventors of the X STOP and have served on the Medical Board of St. Francis Medical Technologies, Inc. (St. Francis Medical Technologies 2005).

Meanwhile, Kondrashov et al. (2006)⁵⁵ published a 4-year follow study from the Zucherman's trial. However, only 18 patients from the 100 who received X STOP device were reported in this paper. The selection procedure was not reported. No details about outcomes assessment were given nor 95% confidence intervals around the point estimates. The quality appraisal of this paper lets us to reject this publication and their results were not reported in this report.

In the uncontrolled before-and-after case series (Lee et al. 2004⁵⁴; $n=10$) on the use of the X STOP for LSS in elderly patients, no intra-operative complications or site-related postoperative complications such as implant failure, bony failure or infection were reported. A total of 70% of the patients stated that they were satisfied with the surgical outcome⁵⁴.

One non-randomized prospective controlled study³⁹ was retrieved to assess clinical effectiveness and safety for Wallis. This study compared two homogeneous groups of patients, both of which underwent surgery for recurrence of herniated disc after an initial L4-L5 discectomy. One group was treated by a second discectomy alone (Control Group, CG), whereas the other group underwent discectomy and implantation of the first-generation Wallis device (Interventional Group, IG). There were 40 patients in each group. The mean follow-up after the intervention was 3 years and 4 months (range 1-4 years and 8 months). Senegas 2002³⁹ found that the Wallis device resulted in a greater reduction in patient pain than discectomy alone (improvement in VAS score of 74% vs 52%), although it is unclear whether the difference was statistically or clinically significant. Patients receiving the Wallis also had more functional improvement assessed with ODI (from 58.2 ± 22 to 16.4 ± 10) than those only receiving discectomy (from 54.7 ± 16 to 22 ± 11). Patients had the same rate of subsequent operations regardless of whether a discectomy occurred with or without a Wallis implant (7.5%; RR=1; 95% CI 0.22 - 4.66). No significant difference was reported in minor safety outcomes between the two treatment groups (RR 1.17; 95% CI: 0.43 - 3.17).

Based on the limited evidence available for these devices, the MSAC finds interspinous spacer devices:

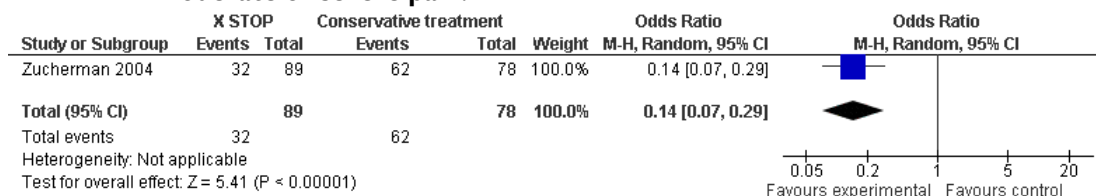
- are as safe as the conventional operations (if the devices were placed without laminectomy the risks and surgical exposure would be less than for conventional laminectomy);
- may be as effective in selected cases as laminectomy and fusion and may be associated with a better outcome in patients with limited or localised (single level) disc disease.

The MSAC concludes that there is insufficient evidence to recommend a change in the public funding arrangements for interspinous devices at this time.

Cochrane systematic review

The Cochrane systematic review¹⁸ only identified the RCT conducted by Zucherman on X STOP. Authors concluded that limited results at one year suggest better outcome estimated on the Zurich Claudication Questionnaire and less pain following device use. Further studies are clearly warranted.

Figure 7.2. Comparison X-STOP vs Conservative treatment Outcome: Moderate or severe pain.



Source: Gibson and Waddell (2005)¹⁸

More generally, authors of this systematic review stated that there is still insufficient evidence on the effectiveness of surgery on clinical outcomes to draw any firm conclusions. There is a need for more scientific evidence on the clinical efficacy and cost-effectiveness of surgical decompression and/or fusion for specific pathological and clinical syndromes associated with degenerative lumbar spondylosis. They recommended high quality RCTs, preferably comparing these surgical treatments with natural history, placebo or conservative treatment.

7.4.1.2 Interventional Procedures Guidance

In 2005, the National Institute for Health and Clinical Excellence (NICE) issued Interventional Procedures Guidance for interspinous distraction procedures for lumbar spinal stenosis causing neurogenic claudication⁵⁶. Only the X STOP was evaluated. This report included the same studies than MSAC (Zucherman et al. 2004, 2005; Lee et al. 2004)^{53,57}. According to the low level of evidence available, this guidance states that there are no major safety concerns associated with implantation of the device, but evidence of efficacy is limited and is confined to the short- and medium-term. NICE recommends limiting the use of this procedure in the context of fully informed patient consent, audit and research. The published guidance further states that specialist advisors questioned the long-term efficacy of the procedure and expressed concerns about additional pain in adjacent levels, device migration, and potential infection.

7.4.1.3 RCTs

Two publications of fair quality were included (Anderson et al. 2006, Hsu et al. 2006)^{58,59}. Both of them compared X STOP to conservative treatment (at least one epidural steroid injection and additional injections at the discretion of the investigator; non steroidal anti-inflammatory drugs, analgesic agents, and physical therapy as needed). These two publications reported secondary analyses of the original Zucherman's trial with the same follow-up duration (2 years) and were published by the same surgical team, who was also the team of the inventors of the X STOP.

No RCT about other interspinous devices was retrieved.

Anderson et al. (2006)⁵⁸ reported results from Zucherman's trial⁵³, in which 191 patients with LSS were enrolled in a prospective 2-year multicenter study and randomized either to the X STOP (n=100) or non-operative group (n=91). Anderson et al. (2006) included 75 patients with degenerative spondylolisthesis among whom 42 underwent surgical treatment (X STOP) and 33 were treated nonsurgically. Two year follow-up data were obtained for 70 of the 75 patients. The outcome measures implemented in the study included ZCQ, patient satisfaction on a scale from 0 to 5 with 0 reflecting the greatest satisfaction, SF-36 and radiographic assessment (Table 7.1.). Successful treatment was defined as improvement in ZCQ of 15 points, patient satisfaction greater than 2.5 and no additional surgery. In the intervention group, the ZCQ score was significantly improved at all postoperative periods in comparison to baseline measurements. A higher satisfaction was observed in the X STOP group at 2 years. This difference was statistically significant. Mental score was not significantly different than that in the normal asymptomatic population, and did not change at 2 years in both groups. Physical score indicated poor function in both groups. Significant improvement was seen in the X STOP group, whereas no change in baseline score was observed in the control group. However, 5 patients with X STOP and 4 patients in the control group further required laminectomy or laminectomy and fusion.

Table 7.1. Outcomes results in X STOP and control groups

	Patient Group	
	X STOP	Control
ZCQ (mean ± SEM)		
baseline	50.40 ± 2.04	51.26 ± 2.39
2 years	23.05 ± 3.14	47.40 ± 3.18
SF-36 PCS (mean ± SEM)		
baseline	31.53 ± 1.68	28.19 ± 1.29
2 years	41.19 ± 1.97	28.14 ± 1.10
SF-36 MCS (mean ± SEM)		
baseline	52.06 ± 1.76	49.92 ± 1.78
2 years	56.29 ± 1.25	49.66 ± 2.22
Patient satisfaction (mean ± SEM)		
2 years	1.55 ± 0.11	2.80 ± 0.18
Clinical success (%)		
2 years	63.4	12.9

The difference between surgical rates in the two groups was not statistically different. There was one procedure-related adverse event in the X STOP device group, an incisional complication that resolved after 1 week of oral antibiotic therapy. Moreover, there was one device-related adverse event, a malpositioned implant that was later detected on radiographic examination. In this study, authors concluded that the X STOP was more effective than non operative treatment in the management of NIC secondary to degenerative lumbar spondylolisthesis. They also considered this device safe since complications were few and easily treated. However, result analysis is problematic as an intention-to-treat strategy was not applied. Instead, the authors reported only on patients with a grade I spondylolisthesis, while randomized patients also included cases of spinal stenosis, and no justification for such subgroup analysis was provided. Thus, the external validity of their conclusions is unknown, but most probably limited.

The second RCT (Hsu et al. 2006)⁵⁹ was conducted to compare the quality of life (QoL) in patients with neurogenic intermittent claudication (NIC) secondary to lumbar spinal stenosis (LSS). This paper reported QoL results from Zucherman's trial⁵³. The SF-36 survey was used to assess the QoL before treatment and at 6 weeks, 6 months, 1 year, and 2 years post-treatment. The questionnaire is composed of eight domains: Physical Functioning (PF) addresses the presence and severity of a patient's physical limitation, and the Role Physical domain (RP) pertains to health related limitations in the type or amount of work a patient can perform. Bodily Pain (BP) involves the frequency and magnitude of the pain, and the General Health domain (GH) tackles patients' assessments of their overall health. Vitality (VT) is a measure of a patient's energy level and Social Function (SF) is used to assess health-related effects on social activities. Role Emotional (RE) measures the impact of emotional problems on work and other daily activities, and Mental Health (MH) includes questions from each of the four major mental health dimensions: anxiety, depression, loss of behavioural or emotional control, and psychological well-being. The physical domains such as PF, RP, and BP are often responsive to the benefits of surgery, and the mental health domains are more responsive to treatments for mental disorders.

Outcomes were assessed for 82 patients in the X STOP group and 53 patients in the non operative group (Table 7.2.). At all post-treatment time points, the authors observed the following: (1) mean domain scores in X STOP-treated patients were significantly greater than those in patients treated non-operatively, with the exception of the mean General Health, Role Emotional, and Mental Component Summary scores at 2 years; and (2) mean post-treatment domain scores in X STOP-treated patients were significantly greater than mean pre-treatment scores, with the exception of mean General Health scores at 6, 12, and 24 months. The results of this study indicate that the X STOP device is significantly more effective than non-operative therapy in improving the QoL in patients with LSS. This study did not report safety outcomes. However, it is important to note that this 2-year follow-up SF-36 data were analyzed for only 82 X STOP-treated patients and 53 nonoperatively treated patients, compared to the 191 randomized in the pilot study (100 in the X STOP group and 91 in the control group); four patients in the X STOP group died of causes unrelated to the implant, in one the implant was removed without further surgery, six underwent a laminectomy, six failed to complete the questionnaire, and one withdrew from the study. In the nonoperative group, three patients died of causes unrelated to the treatment, 24 underwent a laminectomy, six failed to complete the questionnaire, and five withdrew from the study.

Table 7.2. Pre-assessment and post-assessment (2 years) SF-36 scores

	X STOP group		Control group	
	Pre-op	2 years	Pre-op	2 years
PF*	31.7	59.3	33.9	41.4
RP*	13.5	51.4	19.5	28.2
BP*	24.5	53.8	27.4	34.5
GH	70.2	69.9	67.6	64.5
VT*	45.2	58.3	42.9	49.7
SF*	58.8	81.2	64.3	70.4
RE	52.0	73.4	52.2	61.7
MH*	74.8	79.7	72.4	73.2
PCS*	27.8	38.4	28.9	31.2
MCS	51.5	54.3	51.1	52.5

* p < 0.05

7.4.1.4 Before-and-after studies

Only four additional primary studies were retrieved, three of them assessed the clinical effectiveness of X STOP device with a follow-up of minimum 1 year⁶⁰⁻⁶² while the fourth⁶³ examined the outcomes of patients undergoing a disc excision and implantation of a Wallis. No study about Coflex or DIAM corresponding to our inclusion criteria was retrieved.

Kuchta et al. (2009)⁶¹ followed 175 patients with neurogenic intermittent claudication due to LSS. In these patients, X STOP device was implanted in one or two levels. The clinical outcome of patients was assessed during a follow-up period of 2 years. The mean VAS score (leg pain) was reduced from 61.2 ± 29.8 (range 20-100) to 39 ± 28.3 (range 0-75) ($p < 0.001$) at 24 months postoperatively. Mean Oswestry Disability score declined from 32.6 ± 16.0 (range 8-80) to 20.3 ± 17.5 (range 0-42) ($p < 0.001$) at 24 months postoperatively. The number of patients for which an improvement is recorded was not reported, nor the adjustment for potential confounding factors. In eight out of the implanted 175 patients (4.6%), the X STOP had to be removed and a microsurgical decompression had to be performed because unsatisfactory effect. Authors recommended reserving this surgical technique to highly selected patients with a typical clinical picture of positional-dependent claudication with a relief of symptoms during flexion.

Brussee (2008)⁶⁰ also conducted a before-and-after-study to assess the effectiveness of X STOP, in 65 patients meeting the criteria for classical neurogenic claudication due to a lumbar spinal stenosis. The clinical outcome of patients was self-assessed during a follow-up period of 1 year, using the Zürich Claudication Questionnaire. The walking distance was self-assessed according to one question of the physical function scale of the ZCQ. Pre-operatively, 34% of patients were able to walk more than 250 m (no patient was able to walk more than 3 km). Postoperatively, 62% of patients were able to walk more than 250 m (including 16% of patients able to walk more than 3 km) ($\chi^2 = 9.34$; $df = 1$; $p = 0.0022$). A good patient's satisfaction was achieved when the satisfaction score was at least moderately satisfied (mean score 2.0 or less), the severity score was at least improved 0.5 as was the vitality score. Globally, 30.6% of the patients were 'very satisfied' and 74.2% patients reported to be very or moderately satisfied. Overall satisfaction was not influenced by the amount of X STOP ($p = 0.771$). Among patients, 9.2% had a reoperation because of persistent or recurrent symptoms.

Siddiqui et al. (2007)⁶² reported on the one year results of a prospective observational study of the X STOP interspinous implant for the treatment of lumbar spinal stenosis. Forty consecutive patients were enrolled and surgically treated with X STOP implantation. Two patients were excluded from the study because conversion to surgical decompression was required due to intraoperative fracture of spinous processes during the X STOP procedure. One patient was declared unfit for surgery due to medical comorbidities and was also excluded. The X STOP device was implanted at the stenotic segment, which was either at 1 or 2 levels in each patient. Patients were evaluated preoperatively and at three months, six months and one year, using the ZCQ, ODI, and SF-36. Only 24 of 37 patients completed the full set of questionnaires. At a mean follow-up of 12 months, mean ODI scores had improved from 48 to 37, mean ZCQ Symptom Severity scores improved from 3.4 to 2.8, and mean ZCQ Physical Function scores improved from 2.5 to 2.2. Improvements were observed in five of the ten SF-36 sub-scores. This study does not state whether any of the improvements noted were statistically significant, however. The X STOP was removed in two patients who were noted to have dorsally slipped implants at one year, with symptoms of neurogenic claudication. Both patients were treated with decompression and fusion. Twenty-nine percent of patients required caudal epidural after 12 months for recurrence of their symptoms of neurogenic claudication. The investigators noted that, although this study indicates that the X STOP offers significant short-term improvement, these results were less favourable than the previous randomized clinical study. Limitations of this study include the lack of a control group, short duration of follow-up and high proportion of dropouts.

Floman (2007)⁶³ conducted a prospective case series study with 37 consecutive patients who underwent primary lumbar disc excision followed by fixation of the segment with the Wallis implant. Indications for implanting the Wallis device were a voluminous disc herniation and preservation of at least 50% of disc space height. Average follow-up after surgery was 16 months (range 12 to 24). The last 14 patients were also evaluated by the preoperative and postoperative Oswestry Disability Index (ODI) questionnaire, the SF-36 survey, and by a visual analogue scale (VAS) for back and leg pain. In this last group, the average ODI dropped from 43 to 12.7 ($p<0.05$). The average VAS for back pain dropped from 6.6 to 1.4 and the average VAS for leg pain dropped from 8.2 to 1.5 ($p<0.05$). Among all operated patients, 5 patients with relapsing leg pain were diagnosed by MRI as suffering from recurrent herniation (5/37, 13%). All reherniations occurred between 1 and 9 months after the index surgery. Two of the 5 patients subsequently underwent additional discectomy and fusion.

Table 7.3 summarizes the results of our literature review of the clinical studies performed to determine the clinical and safety outcomes after treatment with either X STOP or Wallis.

For each study, a level of evidence was given according to the GRADE system that classifies the quality of evidence in one of four levels—high, moderate, low, and very low⁶⁴.

Quality of evidence and definitions

High quality— Further research is very unlikely to change our confidence in the estimate of effect

Moderate quality— Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate

Low quality— Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate

Very low quality— Any estimate of effect is very uncertain

Source: Guyatt et al. 2008⁶⁴

Table 7.3. Review of the literature for studies investigating the clinical and safety outcomes after implantation of either X STOP or Wallis

Authors & Year	No. of Patients	Indication	Op Procedure	Mean FU	Clinical Outcome	Safety outcomes
X STOP						
Kuchta et al. 2009 Prospective case series study Level of evidence: low	175	Lumbar spinal stenosis	X STOP	2 years	Leg pain (VAS) from 61.2 ± 29.8 to 39 ± 28.3 ; $p < 0.001$ ODI from 32.6 ± 16.0 to 20.3 ± 17.5 ; $p < 0.001$	In 4.6% of the patients, the X STOP had to be removed and a microsurgical decompression had to be performed
Brussee et al. 2008 Prospective case series study Level of evidence: low	65	Lumbar spinal stenosis	X STOP	1 year	Walking distance: preoperatively 34% of patients able to walk > 250 m; postoperatively 62% of patients able to walk > 250 m (including 16% of patients able to walk > 3 km); $p = 0.002$ General satisfaction: 30.6% of the patients were 'very satisfied' and 74.2% patients reported to be very or moderately satisfied.	9.2% had a reoperation because of persistent or recurrent symptoms
Siddiqui et al. 2007 Prospective case series study Level of evidence: low	24	Lumbar spinal stenosis	X STOP	12 months	ODI scores from 48 to 37 Mean ZCQ Symptom Severity scores from 3.4 to 2.8 Mean ZCQ Physical Function scores from 2.5 to 2.2. Recurrence of symptoms: 29% of patients required caudal epidural after 12 months	The X STOP was removed in two patients who were noted to have dorsally slipped implants at one year, with symptoms of neurogenic claudication. Both patients were treated with decompression and fusion.

<p>Anderson et al. 2006</p> <p>RCT (sub-analysis)</p> <p>Level of evidence: low</p>	<p>75 patients included 42 in X STOP group</p>	<p>Degenerative spondylolisthesis</p>	<p>X STOP (IG) vs conservative treatment (CG)</p>	<p>2 years</p>	<p>ZCQ: from 50.4 to 23.1 (IG). No significant improvement in the control group.</p> <p>Patient satisfaction Higher in the IG (1.55) than in the CG (2.8). This difference was statistically significant.</p> <p>Overall health status (SF-36) Mental score did not change at 2 years in both groups.</p> <p>Physical score: IG (31.53 ± 1.68) vs. CG (28.19 ± 1.29). Significant improvement was seen in the IG (41.19 ± 1.97), whereas no change in baseline score was observed in the CG (28.14 ± 1.10)</p> <p>Overall clinical success Overall 2-year clinical success in 63.4% of X STOP patients and in 12.9% in control patients.</p> <p>Additional Surgery Five patients in the IG and 4 patients in the CG required laminectomy or laminectomy and fusion. The difference between surgical rates in the two groups was not statistically different.</p>	<p>One procedure-related adverse event in the X STOP device group: an incisional infection.</p> <p>One device-related adverse event: a malpositioned implant.</p>
<p>Hsu et al. 2006</p>	<p>191 patients</p>	<p>Degenerative spondylolisthesis</p>	<p>X STOP (IG) vs conservative</p>	<p>2 years</p>	<p>QoL was assessed for 82 patients in the X Stop group and 53 patients</p>	

RCT (sub-analysis) Level of evidence: low	included 100 patients with X STOP		treatment (CG)		in the non operative group. QoL was significantly higher in IG than in CG; In IG, QoL was significantly higher in post than in pre treatment scores	
Zucherman et al. 2005 RCT (follow-up) Level of evidence: low	174 patients included 93 patients with X STOP	Spinal stenosis (leg, buttock or groin pain with or without back pain, relieved during flexion).	X STOP (IG) vs conservative treatment (CG)	2 years	Changes from baseline at 2 years follow up ZCQ (physical function) : + 44.3% in IG and -0.4% in CG; p < 0.001 ZCQ (severity score) : + 45.4% in IG and +7.4% in CG; p < 0.001 60% in the IG has a clinically significant improvement in symptom severity compared with 19% in the CG; p < 0.001 Additional surgery 6% in the IG and 30% in the CG required laminectomy for unresolved symptoms.	Complications Complication IG CG Intraoperative respiratory distress 1% 0% Ischemic episode 1% 0% Pulmonary oedema 1% 0% Wound dehiscence 1% NA Wound swelling 1% NA Haematoma 1% NA Incision pain 1% NA Injection intolerance NA 1% Symptom flare NA 1% Leg paresthesia NA 2% Increased back pain NA 1% Heart attack NA 1% Device related Malpositioned implant 1% NA

						Implant migration 1% NA Spinous fracture 1% NA Increased pain at implant level 1% NA
Zucherman et al. 2004 RCT (original study) Level of evidence: low	191 patients included 100 patients with X STOP	Spinal stenosis (leg, buttock or groin pain with or without back pain, relieved during flexion).	X STOP (IG) vs conservative treatment (CG)	1 year	SF-36 : better scores in IG than in CG, in post-treatment than in pre-treatment ZCQ (physical function) : improved in 67.4% in IG and 18.8% in CG ZCQ (severity score) : significantly improved in 73.1% in IG and 22.1% in CG ZCQ (clinical success) : in 62.0% in the IG and 11.6% in the CG	Re-operation rate 6% (5/88) No other side-effects or complications
Lee et al. 2004 Uncontrolled before-and-after case series Level of evidence: very low	10	Spinal stenosis	X STOP	11 months	Satisfaction : 70% were at least somewhat satisfied Symptom severity : 40% had a significant improvement in symptom severity Physical function : 10% showed a significant improvement in physical function	No intraoperative complications

Wallis						
Senegas et al. 2002 Non-randomized prospective controlled study Level of evidence: low	80 patients including 40 patients with Wallis	Recurrence of herniated disc	Discectomy alone (CG) vs Discectomy + Wallis (IG)	3 years and 4 months	<p>VAS score: reduction in pain of 74% (IG) vs 52% (CG)</p> <p>ODI: from 58.2±22 to 16.4±10 (IG) / from 54.7±16 to 22±11 (CG)</p> <p>Analgesics use: At follow-up, 20% in CG were no longer taking analgesic medication vs 42.5% in IG.</p>	<p>No major complications</p> <p>Minor safety outcomes:</p> <ul style="list-style-type: none"> - CG: 5% were reoperated due to persistent LBP (lumbar fusion + neurostimulation device). - IG: 17.5% had dural violation; 7.5% underwent a revision procedure (arthrodesis and/or discectomy) for persisting LBP.
Floman 2007 Prospective case series study Level of evidence: low	37	Voluminous disc herniation	Lumbar disc excision + Wallis	16 months (12-24 months)	<p>Outcomes were assessed pre and postoperatively for 14 patients.</p> <p>Back pain (VAS): from 66 to 14 (p<0.05)</p> <p>Leg pain (VAS): from 82 to 15 (p<0.05)</p> <p>ODI: from 43 to 12.7 (p<0.05)</p>	13% of all operated patients were reoperated due to recurrent herniation

*VAS scores were transformed to be read on a scale from 0 to 100 mm

7.4.2 Discussion

The U.S. Food and Drug Administration (FDA) approved the X STOP (St. Francis Medical Technologies, Inc.) through the Pre-market approval (PMA) process on November 2005. The X STOP is indicated for the treatment of patients 50 years and older who have moderately impaired physical function from back and leg pain caused by spinal stenosis and who have obtained little or no pain relief after at least six months of nonsurgical treatments such as pain medications, physical therapy, injections and/or manipulation.

Our literature search, followed by a quality appraisal of retrieved studies, identified four HTA reports and one systematic review describing one randomized clinical trial; two sub-analyses of this original RCT; and, three non randomised uncontrolled before-and-after studies.

The randomised controlled clinical trial had adequate power to evaluate differences in health outcomes relevant to patients suffering from symptoms associated with spinal stenosis. Researchers carefully selected and included patient cohorts for whom pain relief at baseline was achieved in flexion but exacerbated in extension. This selection criterion is very useful to test clinical effectiveness of a new device. However, it reduces the generalizability of the device to be used in all patients with neurogenic claudication, and the potential benefit that the device can provide. For example, a high failure rate (7/12; 58%), defined as surgical re-intervention, was reported in patients with lumbar spinal stenosis resulting from degenerative spondylolisthesis, within 24 months after X STOP placement⁶⁵.

Some methodological issues with this randomized clinical trial were highlighted, limiting the significance of results⁶⁶. First, the immediate drop out of patients randomized to the control group suggests a disappointment of patients who were asked to pursue an unsuccessful conservative treatment. The consequence of this drop out is the loss of the equal distribution of unmeasured confounders in both arms of the study, if they were excluded from the analysis. For the primary outcome, all of these patients were included in the analysis, but considered failures. This clearly biases the results against the non-operative group. Since the primary outcomes of the study were patient self report of symptoms, unsatisfied patients randomized to the control arm were likely to report worse outcomes than those who knew they underwent the surgical procedure.

Two, blinding was a problem because only the evaluating physician, not the patients, treating physician, or radiologist, were blinded. In addition, the randomization was stratified by site with a fixed block size of two, and patients were randomized upon determination of eligibility. With that block size, the investigator can predict which treatment the second patient of each pair in the block will receive. It would have been better to use a variable block size and to not randomize unblinded patients so far in advance of treatment⁶⁷.

Third, the results for the site where the device was invented (St. Mary's Medical Center) had a higher effectiveness success outcome (85%) as compared to the other investigational sites ($\leq 50\%$). Excluding that site, the X STOP success rate was 33%, raising issues of learning curve and patient selection⁶⁷.

Fourth, choosing a control as a traditional non-operative treatment which already failed would allow easy demonstration of greater effectiveness by the interventional patient group. In majority, patients enrolled in the study had failed 2 or more years of conservative therapy and the controls had to pursue the same therapy that was ineffective. Moreover, the conservative therapy delivered to the control arm was not standardized and may not have been state of the art.

Although the sponsor claims that X STOP success rates were comparable to laminectomy results, this comparison was not randomized, and most laminectomy patients were study failures. Laminectomy patients were pooled from dissimilar groups: 30 from the pivotal study, 7 from Pivotal Trial 1, and 7 untreated pivotal study patients⁶⁷.

This randomized controlled trial was the second pivotal trial to obtain the premarket approval by FDA. The FDA panel cited several concerns, including, but not limited to the block randomization, the lower outcomes in both groups, the superiority of outcomes in one centre, the lack of long term follow-up (longer than 2 years) and the need for radiographic or other objective evidence of the device's (mechanical) mechanism of effect on the spine in patients⁶⁶. However, the outcomes were strongly in favor of the X STOP arm and the device-related risks appear small. The FDA panel estimated that the benefits of use of the device for the target population outweigh the risk of illness or injury when used as indicated in accordance with the directions of use.

The uncontrolled before-and-after studies reported limited evidence on the clinical effectiveness and safety of X STOP. Clinical outcomes commonly used to assess response to spinal device implantation include the proportion of patients who reported an improvement in back or leg pain (measured on a 10-point VAS), in function (measured on the Oswestry Disability Index), in symptom severity, physical function and global satisfaction (measured on the Zurich Claudication Questionnaire), and an improvement in functional health and well-being (measured on SF-36 or SF-12 Health Surveys). Other outcomes include the walking distance, the quality of life and the proportion of patients who no longer take analgesics.

Further long-term studies comparing the device to other treatment options are required before the safety and efficacy of this device can be confirmed. Conditions of FDA marketing approval included post-approval studies to obtain 5-year follow-up data from all patients in the PMA clinical trial who received the X STOP implant plus a new cohort of lumbar spinal stenosis patients. This study is expected to include 240 patients at 8 clinical sites.

Too few uncontrolled before-and-after studies reported limited evidence on the clinical effectiveness and safety of Wallis. For this device, further long-term studies comparing the device to other treatment options are also required before the safety and efficacy of this device can be confirmed.

Key points

- **There is low quality evidence on the efficacy of interspinous implants for the treatment of neurogenic claudication due to lumbar spinal stenosis, coming from non-randomised uncontrolled before-and-after clinical studies.**
- **There is limited evidence from one randomised trial indicating that interspinous implant such as X STOP is effective in reducing pain and improving physical function. Moreover, significant positive results were obtained in one original RCT and sub-analyses conducted by inventors of this device.**
- **During a 2 year follow-up, a percentage of patients whose symptoms improved at 6 and 12 months showed a trend of regression of pain and physical function symptoms toward baseline levels at 24 months that questioned the long-term efficacy of the device.**
- **Clinical studies suffered from important methodological weaknesses which questioned the reliability of results:**
 - **All studies recorded high drop-out rates without analysis of the losses to follow-up**
 - **All efficacy outcomes were subjective self-reported scales**
 - **No follow-up was longer than 2 years**
 - **Statistical significance of results was not always reported while clinical significance of results was never discussed**
 - **In a lot of prospective observational studies, no comparator was used**

- In RCT, overall effectiveness of the device was not shown in the majority of the clinical study population while superior results were obtained in medical centres where inventors of X STOP operate
- In RCT, only one comparator was used, i.e. a conservative treatment that failed to relieve symptoms after minimum 6 months
- Clinical indications for all interspinous devices need to be clearly defined.
- Studies retrieved recorded high failure rates requiring further decompression surgery and/or fusion.
- It is uncertain whether the implants can be safely removed.
- At present and until the results of high-quality primary research become available, this technique has to be considered experimental, and should ideally be limited to carefully selected patients treated in clinical trials in research centres.
- Further long-term studies comparing the device to other treatment options are required before the safety and efficacy of this device can be established. Additionally to validated assessment questionnaires, objective clinical outcomes have to be assessed (e.g. walking distance, return to work/sick leave).

7.4.3 For pedicle screws

7.4.3.1 HTA reports

Only one potential good quality HTA report was identified³⁵.

Medical Services Advisory Committee HTA Report (Australia, 2007)

This HTA report focused on Dynesys. The literature search conducted up until April 2006 retrieved two medium-quality historically controlled studies^{68,69}. Six uncontrolled before-and-after case series assessed the effectiveness and the safety of the Dynesys device⁷⁰⁻⁷⁵.

One historically controlled study (Putzier et al. 2005)⁶⁹ examined the effect of dynamic stabilization on the progression of segmental degeneration after nucleotomy. A total of 84 patients suffering from lumbar radicular pain underwent nucleotomy of the lumbar spine for the treatment of symptomatic disc prolapse. Additional dynamic stabilization (the Dynesys system) was performed in 35 subjects. All patients showed signs of initial disc degeneration (Modic I). Evaluation was carried out before surgery, 3 months after surgery, and at follow-up. The mean duration of follow-up was 34 months. Examinations included radiographs, MRI, physical examination, and subjective patient evaluation using Oswestry score and VAS. The neurologic examination at follow-up showed in 74.3% of Dynesys group (26 of 35 patients) and in 71.4% of control group (35 out of 49 patients) a complete remission of the preoperative symptoms (no significant difference). An equal degree of improvement in clinical symptoms, Oswestry score, and VAS was reported in both groups after 3 months (only graphs were reported). Between 3 months and follow-up, a significant but slight increase in the Oswestry score and in the VAS was seen only in the control group ($p < 0.05$). In the dynamically stabilized group, no progression of disc degeneration was noted at follow-up, while radiological signs of accelerated segmental degeneration existed in the solely nucleotomized group. There were no implant-associated complications. Although the authors concluded that the Dynesys system is useful to prevent progression of degenerative disc disease following nucleotomy, this study was non-randomized and the treatment group was retrospectively compared with patients treated only with nucleotomy before the availability of the Dynesys system. Moreover, it is important to recall that Dynesys is intended to be an alternative to fusion (with decompression being carried out at the same time) and not as an alternative to decompression surgery alone, such as nucleotomy. The comparison made in this study is not really appropriate to test the efficacy of Dynesys.

A second German historically controlled study (Cakir et al. 2003)⁶⁸ performed in patients with spinal stenosis with degenerative lumbar instability compared Dynesys and fusion with Krypton® (a rigid PLF system; autologous bone graft harvested from the iliac bone crest). Sample size of this study was small: 10 patients in fusion group (data was collected retrospectively for this group) and 10 patients with a minimum follow-up of 12 months from a total of 24 patients treated with Dynesys. Decompression was performed by removing the ligamentum flavum and by undercutting the hypertrophic facet joints. Authors reported that spinal fusion was slightly more effective at reducing pain after 14 months, although the statistical and clinical significance of this difference is unclear. However, 3 of 10 patients who underwent fusion complained of considerable postoperative pain associated with the site of the bone graft. By 14 months follow-up, Cakir et al. (2003)⁶⁸ found that patients who received the Dynesys system and those who received fusion had mean ODI scores evolved from scores corresponding to severe disability to moderate disability. Improving quality of life was recorded for both treatment groups. Cakir et al. (2003)⁶⁸ did not assess the statistical significance of the change after intervention or the difference between the groups due to small sample size.

These two studies also compared the rate of complications between Dynesys with decompression compared to decompression with or without fusion. No major adverse events were reported in either treatment group, and there was little difference in the rate of minor complications found between the treatment groups. The most common minor complications reported were dural lesions which occurred intra-operatively (without permanent post-operative symptoms) and superficial infections. No patients in either treatment group had any breakage or dislodgement of screws.

Six uncontrolled case series also assessed the effectiveness and the safety of this device. The results from the study of Putzier (2004)⁷² were updated in Putzier et al. (2005)⁶⁹. Only the more recent results were presented.

In France, Dubois et al. (1999)⁷⁰ recruited 57 consecutive patients with lumbar instabilities in one hospital for an uncontrolled study that assessed effectiveness of Dynesys. Pain was measured on a four point scale (from none to severe), analgesic use on four point scale (from never to several times each day), McNab's functional criteria (from 'excellent = no pain, no restriction of movement, patient can work normally' to 'poor = no progress'), and persistence of sciatica. Mean follow-up was 13 months (range 2-31 months). Comparing preoperative and postoperative results, authors found no significant difference regarding pain ($p=0.23$), intake of analgesics ($p=0.31$), or the McNab score ($p=0.24$). Sciatica reduction was described as 'remarkable', but no p-value is given in the paper. In 4/57 (7%) patients, the device had to be removed, and replaced by an arthrodesis on three levels. In another two, one of the pedicle screws had been placed in extrapedicularly resulting in neurological symptoms. No complications related to the material were found.

A prospective, multi-center study (Stoll et al. 2002)⁷¹ evaluated the safety and efficacy of Dynesys in the treatment of lumbar instability conditions on a consecutive series of 83 patients. Indications consisted of unstable segmental conditions, mainly combined with spinal stenosis (60.2%). Thirty-nine patients additionally had degenerative spondylolisthesis, and 30 patients had undergone previous lumbar surgery. In 56 patients instrumentation was combined with direct decompression. The mean follow-up time was 38.1 months (range 11.2-79.1 months). Mean pain and function scores improved significantly from baseline to follow-up, as follows: back pain scale from 7.4 to 3.1, leg pain scale from 6.9 to 2.4, and Oswestry Disability Index from 55.4% to 22.9%. At baseline, 48% (35/73) were totally incapacitated but only 3% (2/73) remained so at a mean follow up of 38 months. There were nine complications unrelated to the implant, and one due to a screw malplacement. Four of them required an early surgical reintervention.

Additional lumbar surgery in the follow-up period included: implant removal and conversion into spinal fusion with rigid instrumentation for persisting pain in three cases, laminectomy of an index segment in one case and screw removal due to loosening in one case. In seven cases, radiological signs of screw loosening were observed. In seven cases, adjacent segment degeneration necessitated further surgery.

Bordes-Monmeneu et al. (2005)⁷³ also presented a series of 94 patients in whom Dynesys system was used; the main pathologies diagnosed were degenerative disc disease (57%), disc hernia (29%) and canal stenosis (14%). Follow-up period was 14 to 24 months and patients outcomes were evaluated using Oswestry scale and return to work. Oswestry scale results were 21.4% post-operatively, compared with 56.8% previous to treatment. Recovery permitting return to work occurred in 82% of patients. Return to work became more difficult, depending on the demands of the activity involved: 95% in sedentary work (desk jobs, civil servant jobs ...), 90% in average activities (domestic activities, care work, etc., requiring movement but not the need to carry loads) and 68% in heavy work (construction, driving heavy loads, loading and unloading, elite-class athletics, etc.). Sciatic nerve condition and lumbalgia remitted in practically all cases and there was 60% improvement in cases of claudication. Two cases of complications due to the technique were reported, one due to malpositioning of screws and another due to pedicle breakage. Two cases of subcutaneous seroma and two tardive subclinical infections were also observed.

Grob et al. (2005)⁷⁴ reported results of a smaller retrospective case series of 31 patients with degenerative disease followed up to 2 years, 67% of patients reported that back symptoms had resolved or improved and 3% reported these getting worse. Within the 2-year follow-up period, 19% required further surgical intervention. At follow-up, mean back and leg pain were 4.7 and 3.8, respectively. Pre-operative VAS pain intensity scores could not be compared with scores at follow-up due to methodological differences. Six of 31 patients either required reintervention in the 2-year follow-up or were undergoing evaluation for re-operation in the near future. The investigators concluded that both back and leg pain are, on average, moderately high 2 years after instrumentation with the Dynesys system and that overall patient oriented results were poorer than those for historic controls undergoing fusion for similar indications at their center. The investigators concluded that these results provide no support for the notion that semi-rigid fixation of the lumbar spine resulted in better patient-oriented outcomes than those typical of fusion.

Schnake and colleagues (2006)⁷⁵ reported on a small prospective case series study consisting of 26 patients (mean age 71 years) with lumbar spinal stenosis and degenerative spondylolisthesis. Patients underwent decompression and dynamic stabilization with the Dynesys system. The minimum follow-up was 2 years. The authors reported significant improvements in leg pain ($p < 0.01$) and mean walking distance improved significantly to more than 1000 m ($p < 0.01$). However, a significant number of patients (21%) reported continuing claudication. No significant progression of spondylolisthesis was detected, but an implant failure rate of 17% was reported, none of them being clinically symptomatic. The authors concluded that results with the Dynesys device in addition to decompression in elderly patients with spinal stenosis with degenerative spondylolisthesis were comparable to clinical results seen with standard decompression and fusion techniques. They did acknowledge that the study was limited by a small number of patients, short follow-up, and lack of randomized controls.

Based on the limited evidence available for this device, the MSAC finds that the Dynesys:

- is as safe as laminectomy with spinal fusion, noting that although there appears to be less blood loss with the use of Dynesys, there is a slightly higher incidence of loosening of the pedicle screws;
- is no more effective in selected cases than laminectomy and fusion, and requires almost the same surgical exposure;

The MSAC concludes that there is insufficient evidence to recommend a change in public funding arrangements for Dynesys at this time.

Subsequently to the low level of evidence available about Dynesys, no firm conclusion about safety and/or efficacy can be drawn. Therefore, MSAC conclusions about safety of this non fusion pedicle screw device are not evidence-based. Further long-term studies comparing the device to other treatment options are required before the safety and efficacy of this device can be confirmed.

7.4.3.2 *Interventional Procedures Guidance*

In 2006, the National Institute for Health and Clinical Excellence (NICE) issued *Interventional Procedures Guidance* for non-rigid stabilization procedures for the treatment of low back pain⁴⁴. Dynesys and Graf ligament were evaluated in a systematic review. Concerning Dynesys, this report included two studies also included in MSAC report (Stoll et al. 2002; Grob et al. 2005)^{71,74}.

In this guidance, NICE (2006)⁴⁴ stated that "current evidence on the safety of these procedures is unclear and involves a variety of different devices and outcome measures. Therefore, these procedures should not be used without special arrangements for fully informed patient consent and for audit or research". Additionally, the specialist advisors to the Institute's *Interventional Procedures Advisory Committee* noted that these procedures may be undertaken concurrently with disc decompression or discectomy. Thus, it is difficult to ascertain what clinical benefit is derived from the implants themselves. Moreover, there is little data available on long-term efficacy. The specialist advisors noted that the reported adverse events include infection, mal-positioned or broken screws leading to nerve root damage, cerebrospinal fluid leak, failure of the bone/implant interface, and failure to control pain. The theoretical risks with the techniques include: device failure (particularly long term), increased lordosis, and root damage caused by loose or misaligned screws.

7.4.3.3 *Systematic reviews*

No systematic review was found for pedicle screws.

7.4.3.4 *RCTs*

No RCT was found for pedicle screws.

7.4.3.5 *Before-and-after studies*

Only four additional primary studies were retrieved, assessing the clinical effectiveness and safety of Dynesys with a follow-up of minimum 1 year⁷⁶⁻⁷⁹.

Lee et al. (2008)⁷⁶ assessed the safety and efficacy of the Dynesys system in the treatment of degenerative spinal diseases (spinal stenosis with degenerative spondylolisthesis, degenerative spinal stenosis, adjacent segmental disease after fusion, spinal stenosis with degenerative scoliosis and recurrent intervertebral lumbar disc herniation). This study included 20 consecutive patients with a mean age of 61 ± 6.98 years (range 46-70) who underwent decompression and dynamic stabilization with the Dynesys system. All of the patients completed the visual analogue scale (VAS) and the Korean version of the ODI (Table 7.4.). The mean follow-up period was 27.25 ± 5.16 months (range 16-35 months), and 19 patients (95%) were available for follow-up. One patient had to have the implant removed. There were 30 stabilized segments in 19 patients. The VAS significantly decreased and 11 patients (57.8%) were completely free of back and leg pain. The patients' mean score on the Korean version of the ODI also improved significantly. Following complications were reported: 6 patients with dural tear during decompressive procedure; 1 patient developed dysarthria and facial palsy at 8 days postoperative and was diagnosed with an acute infarction of the left corona radiata of the cerebrum; in one patient, the implant needed to be removed due to a delayed allergic reaction 10 months after the operation. There were no implant failures, such as pedicle fracture, screw loosening or screw malposition, as of the last follow-up.

Table 7.4. Assessed outcomes before and after Dynesys implantation⁷⁶

Assessed outcomes	Preoperative	Postoperative	p value
Back and leg pain (VAS)	8.55 ± 1.21	2.20 ± 1.70	< 0.001
ODI (%)	79.58 ± 15.93	22.17 ± 17.24	< 0.001
Number of analgesics	19	5	

Schaeren et al. (2008)⁷⁷ tested whether posterior dynamic stabilization in situ with Dynesys can maintain enough stability to prevent progression of spondylolisthesis in long-term follow-up (4 years). The two-year results in this population were already reported by Schnake et al. (2006)⁷⁵. Twenty-six consecutive patients with symptomatic lumbar spinal stenosis and degenerative spondylolisthesis underwent interlaminar decompression and stabilization with Dynesys. Patients were evaluated after a minimum follow-up of 4 years and 19 patients could be evaluated with a mean follow-up of 52 months (range, 48–57 months) (Table 7.5.). Pain on VAS improved significantly at 2 years as walking distance and remained unchanged at 4 years follow-up. Neurological symptoms were significantly improved and the use of pain medication significantly reduced. During the follow-up, 4/19 patients were re-operated (21%): for insufficient decompression (1), for osteoporotic fractures after falls (2), due to adjacent segment disability (1). Screw loosening was reported in 3 patients (11%). At 4 years follow-up, 47% of the patients showed new signs of degeneration at adjacent levels. In addition, progressive degeneration at the level next to the adjacent segment was seen in eight patients. These data show that dynamic stabilization cannot prevent adjacent segment degeneration either. It remains unclear if adjacent segment degeneration is due to the high intrinsic stability of the system which probably acts similarly to a rigid pedicle screw system and can overload the adjacent motion segments or more a consequence of the natural aging process.

Table 7.5. Assessed outcomes 4 years after Dynesys implantation

Assessed outcomes	Preoperative	4 years follow-up	P value
Pain (VAS)	80	25	< 0.001
Mean walking distance (m)	250m	>1000m	< 0.01
Number of patients using analgesics	19	6	0.013

Würgler-Hauri et al. (2008)⁷⁹ reported the outcomes and complications in patients undergoing microsurgical radicular decompression and implantation of Dynesys. This study included a total of 37 consecutive patients (mean age 58 years) presenting with acquired lumbar stenosis, signs of segmental instability, and degenerative disc disease. Lumbar and radicular pain was present in 33 patients (92%). One patient was lost to follow-up. All patients underwent lumbar microsurgical decompression and implantation of Dynesys in 1 (n=10), 2 (n=17), 3 (n=9), and 4 segments (n=1). Decompressive surgery was not standardized and included total laminectomy (11%), hemilaminectomy (3%), discectomy (16%), medial facetectomy (6%), unilateral laminotomy (30%), and bilateral laminotomy (54%). Nine (24%) patients required additional decompression or discectomy in adjacent segments to the level in which Dynesys was implanted. Clinical evaluation included VAS (leg and back), distribution and severity of pain (%), Prolo Functional (from 1=Total incapacity, worse than preop to 5=Complete recovery, no episodes of recurrent low back pain & able to perform all previous sports activities) and Prolo Economic Status (from 1=Complete invalid to 5=Able to work at previous occupation w/ no restrictions), Stauffer Coventry Scale (used to measure 'return to work' and 'quality of work' outcomes), patient's self evaluation, at 3 and 12 months. Leg and back pain (visual analog scale) improved at 12 months from 8.4±2.1 to 3.1±1.4 and from 6.7±2.8 to 4±2.8, respectively. Overall pain severity improved due to reduction of radicular pain from 59.2% to 27.3% after microsurgical decompression. Meanwhile, lumbar pain deteriorated from 40.8% to 47.8%. Twenty-seven percent (patient's self-evaluation) and 29.7% (Stauffer Coventry Scale) of the patients described a fair or poor outcome. Moreover, 51% and 54% of the patients had a Prolo Economic Status and Prolo Functional of 4 or 5, respectively. Complications included 4 broken and 2 misplaced screws from a total of 224 screws implanted, 2 loosen systems, and 1 cerebrospinal fistula. At 1-year, a total of 7 patients (19%) required surgical revision.

Welch and colleagues (2007)⁷⁸ presented the preliminary clinical outcomes of dynamic stabilization with the Dynesys spinal system as part of a multicenter randomized prospective FDA investigational device exemption (IDE) clinical trial. This study included 101 patients from six IDE sites (no participants were omitted from the analysis) who underwent dynamic stabilization of the lumbar spine with the Dynesys construct (after

decompression if necessary). Patient participation was based on the presence of degenerative spondylolisthesis or retrolisthesis (Grade I), lateral or central spinal stenosis, and their physician's determination that the patient required decompression and instrumented fusion for one or two contiguous spinal levels between L1 and S1. Patients were evaluated preoperatively, postoperatively at 3 weeks, and then at 3-, 6- and 12-month intervals. The 100-mm VAS was used to score both lower limb and back pain. Patient functioning was evaluated using the ODI, and the participants' general health was assessed using the Short Form-12 questionnaire. Overall patient satisfaction was also reported. The mean pain and function scores improved significantly from the baseline to 12-month follow-up evaluation, as follows: leg pain improved from 80.3 to 25.5 ($p<0.01$), back pain from 54 to 29.4 ($p<0.01$), and ODI score from 55.6% (range 0-94%) to 26.3% (range 0-94%). Mean SF-12 increased both for mental score (from 41.6 to 49.4; $p<0.01$) and for physical score (from 27.3 to 40.3; $p<0.01$). However, a high rate of intra-operative complications was reported ($n=16$; 15.8%): 12 were dural tears, 2 cases of excessive blood loss requiring transfusion, 1 patient suffered an allergic reaction to anaesthesia; and 1 was a fractured pedicle, which occurred during screw insertion. Moreover, 15 (15%) of 101 patients required 18 re-interventions by the time of the 1-year follow-up evaluation. 10 of the 18 re-interventions were revision surgery (decompression, extension of the segmental fixation, or removal of extradural synovial facet cyst) at the same spinal level due to radiculopathy, increased back pain, or increased instability. In 3 of these 10 re-interventions, removal of the stabilization system was required.

The same authors⁸⁰ published the twenty-four months results of this IDE study, as an abstract form. This abstract reported the outcomes of 253 patients following dynamic stabilization with Dynesys and concluded that at 24 months, the subjects implanted with the Dynesys showed an improvement in ODI, Neurological Success, and SF-12 scores and a significant improvement in leg pain, back pain, and SF-12 Physical Component scores.

Table 7.6 summarizes the results of our literature review of the clinical studies performed to determine the clinical and safety outcomes after treatment with the Dynesys spinal system.

For each study, a level of evidence was given according to the GRADE system that classifies the quality of evidence in one of four levels—high, moderate, low, and very low⁶⁴.

Quality of evidence and definitions

High quality— Further research is very unlikely to change our confidence in the estimate of effect

Moderate quality— Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate

Low quality— Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate

Very low quality— Any estimate of effect is very uncertain

Source: Guyatt et al. 2008⁶⁴

Table 7.6. Review of the literature for studies investigating the clinical and safety outcomes after implantation of the Dynesys spinal system

Authors & Year	No. of Patients	Indication	Op Procedure	Mean FU	Clinical Outcome	Safety outcomes
<p>Würgler-Hauri et al. 2008</p> <p>Before-and-after clinical study</p> <p>Level of evidence: low</p>	37	lumbar stenosis, signs of segmental instability, and degenerative disc disease	Decompression + Dynesys	1 year	<p>leg pain (VAS) from 84±21 to 31±14</p> <p>back pain (VAS) from 67±28 to 40±28</p> <p>pain severity from 59.2% to 27.3%</p> <p>lumbar pain from 40.8% to 47.8%</p> <p>Stauffer Coventry Scale: fair or poor outcome in 29.7% of patients</p> <p>Prolo Economic Status: 51% had excellent scores (4 or 5)</p> <p>Prolo Functional: 54% had excellent scores (4 or 5)</p>	<p>Complications included 4 broken and 2 misplaced screws from a total of 224 screws implanted, 2 loosen systems, and 1 cerebrospinal fistula.</p> <p>7 patients (19%) required surgical revision</p>
<p>Lee et al. 2008</p> <p>Before-and-after clinical study</p> <p>Level of evidence: low</p>	20	spinal stenosis with degenerative spondylolisthesis, degenerative spinal stenosis, adjacent segmental disease after fusion, spinal stenosis with degenerative scoliosis and recurrent intervertebral lumbar disc herniation	Decompression + Dynesys	27.25 ± 5.16 months (16-35 months)	<p>leg and back pain (VAS) from 85.5 ± 12.1 to 22.0 ± 17; p< 0.001</p> <p>ODI (%) from 79.58 ± 15.93 to 22.17 ± 17.24; p< 0.001</p> <p>Number of analgesics from 19 to 5</p>	<p>8 complications were reported: 6 patients with dural tear during decompressive procedure; 1 patient developed dysarthria and facial palsy; in 1 patient, the implant needed to be removed due to an allergic reaction</p> <p>no implant failures</p>
<p>Welch et al. 2007</p> <p>Before-and-after clinical study</p> <p>Level of evidence: low</p>	101	degenerative spondylolisthesis or retrolisthesis (Grade I), lateral or central spinal stenosis	Decompression (if necessary) + Dynesys	1 year	<p>leg pain (VAS) from 80.3 to 25.5; p<0.01</p> <p>back pain (VAS) from 54 to 29.4; p<0.01</p> <p>ODI from 55.6% (range 0-94%) to 26.3% (range 0-94%).</p> <p>SF-12 (MCS) from 1.6 to 49.4;</p>	<p>A high rate of intra-operative complications was reported (15.8%): 12 were dural tears, 2 cases of excessive blood loss requiring transfusion, 1 patient with allergic reaction; and 1 was a fractured pedicle, which</p>

					p<0.01 SF-12 (PCS) from 27.3 to 40.3; p<0.01	occurred during screw insertion. 15 (15%) of 101 patients required 18 re-interventions (revision surgery at the same spinal level due to radiculopathy, increased back pain, or increased instability). In 3 re-interventions, removal of the stabilization system was required.
Schaeren et al. 2008 Before-and-after clinical study (Follow-up of Schnake et al. 2006) Level of evidence: low	26	lumbar stenosis, degenerative spondylolisthesis	Decompression + Dynesys	4 years	Pain (VAS): from 80 to 25; p< 0.001 Mean walking distance (m): from 250m to >1000m; p< 0.01 Patients using analgesics: from 19 to 6; p=0.013	21% of patients were re-operated for insufficient decompression (1), for osteoporotic fractures after falls (2), due to adjacent segment disability (1). Screw loosening was reported in 3 patients (11%). 47% of the patients showed new signs of degeneration at adjacent levels + degeneration at the level next to the adjacent segment (8 patients)
Schnake et al. 2006 Before-and-after clinical study Level of evidence: low	26	lumbar stenosis, degenerative spondylolisthesis	Decompression + Dynesys	2 years	Leg pain (VAS) from 80 to 23 Walking distance significantly increased Satisfaction: 87.5% would undergo the same procedure again	17%: implant failure rate (not symptomatic)
Bordes-Monmeneu	94	Lumbar stenosis, DDD,	Decompression +	14 to 24	ODI from 56.8% to 21.4%	Two cases of complications

et al., 2005 Before-and-after clinical study Level of evidence: low		disc herniation	Dynesys	months	Return to work: 82% of all patients	due to the technique were reported (malpositioning of screws and pedicle breakage). Two cases of subcutaneous seroma and two tardive subclinical infections
Grob et al. 2005 Before-and-after clinical study Level of evidence: low	31	Degenerative disease (disc/stenosis) with associated instability	Decompression + Dynesys in 13 patients; Dynesys alone in 18 patients	2 years	Mean back and leg pain were 4.7 and 3.8 at follow-up	19% either required reintervention in the 2-year follow-up or were undergoing evaluation for re-operation in the near future
Putzier et al. 2005 Historically controlled study Level of evidence: low	35	Disc prolapse with lumbar radicular pain	Nucleotomy + Dynesys	34 months	Back and lower-limb pain (VAS): significant improvement ODI: significant improvement	No implant-associated complications
Cakir et al. 2003 Historically controlled study Level of evidence: low	10	Spinal stenosis with degenerative lumbar instability	Decompression + Dynesys	12 months	ODI: from severe to moderate disability QoL: improvement	No major adverse events
Stoll et al. 2002 Prospective multicenter study Level of evidence: low	83	Unstable segmental condition (lumbar stenosis, degenerative spondylolisthesis, DDD)	Decompression + Dynesys	38.1 months (11.2 – 79.1 months)	Back pain (VAS) from 74 to 31 Leg pain (VAS) from 69 to 24 ODI from 55.4 to 22.9 Totally incapacitated from 48% to 3%	One complication due to a screw malplacement. Additional lumbar surgery in the follow-up: implant removal and conversion into spinal fusion, laminectomy of an index segment in one case and

						<p>screw removal due to loosening in one case</p> <p>In seven cases, screw loosening</p> <p>In seven cases, adjacent segment degeneration necessitated further surgery.</p>
<p>Dubois et al. 1999</p> <p>Before-and-after clinical study</p> <p>Level of evidence: low</p>	57	DDD	Decompression + Dynesys	13 months (2 – 31 months)	<p>Pain, activity level (MacNabe score) and intake of analgesics:</p> <p>no difference between preop and postop</p>	No major adverse events

*VAS scores were transformed to be read on a scale from 0 to 100 mm

Key points

- There is low quality evidence on the efficacy of non fusion pedicle screw based systems for the treatment of degenerative spondylolisthesis or symptomatic lumbar spinal stenosis, coming from non-randomised before-and-after clinical studies.
- Most clinical studies were uncontrolled and did not use an adequate comparator. They included a large mix of patients presenting with heterogeneous indications.
- All efficacy outcomes were subjective self-reported scales. Only one prospective study assessed return to work after surgery, with higher rate obtained in sedentary activities (95%) than in heavy activities (68%).
- Because these procedures may be undertaken concurrently with disc decompression or discectomy, it is difficult to ascertain what clinical benefit is derived from the implants themselves.
- The theoretical advantage of pedicle screw device on fusion, i.e. limiting degeneration of adjacent levels was not confirmed in a 4 year follow-up study: 47% of the patients showed new signs of degeneration at adjacent levels; in addition, in 37% of the patients, progressive degeneration at the level next to the adjacent segment was observed. These data show that dynamic stabilization cannot prevent adjacent segment degeneration either.
- There is little data available on long-term efficacy. The only study that followed patients on a long term (4 years) recorded a 21% re-operation rate (4/19). Screw loosening was reported in 11% of patients (3/19). New signs of degeneration were reported in 47% of patients (9/19).
- Whereas this procedure is theoretically considered as a minimally invasive approach, surgical implantation of pedicle screw devices is still very invasive, with resulting disruption of the muscle and ligamentous structures.
- Concerning safety, studies reported device-related adverse events such as malpositioned or broken screws leading to nerve root damage.
- At present and until the results of high-quality primary research become available, this technique has to be considered experimental, and should ideally be limited to carefully selected patients treated in clinical trials in research centres.
- Further long-term studies comparing the device to other treatment options are required before the safety and efficacy of this device can be established. Additionally to validated assessment questionnaires, objective outcomes have to be assessed (e.g. walking distance, return to work/sick leave).

7.5 ONGOING CLINICAL TRIALS

Clinical trials are currently ongoing to assess efficacy and safety of lumbar non-fusion dynamic stabilization devices.

Two studies are currently ongoing to test X STOP: LTOS Study and COAST Study. They aim to evaluate long term safety and effectiveness of the X STOP in the patients who received the X STOP in the IDE. These patients consist of two cohorts to be evaluated: patients who had moderately impaired physical function prior to X STOP implantation (as determined by a baseline score >2.0 in the physical function domain in the Zurich Claudication Questionnaire), and patients who had mildly impaired physical function prior to X STOP surgery (as determined by a baseline score ≤ 2.0 in the physical function domain in the Zurich Claudication Questionnaire). Pain and function evaluations will be performed annually using the Zurich Claudication Questionnaire, through the fifth postoperative year. Secondary endpoints will include mean scores for the SF-36, and incidence rates of adverse events, device failures, and secondary surgeries.

A US FDA-regulated clinical trial for the DIAM for patients with lumbar spinal stenosis was initiated in late 2006. Also in 2006, the FDA granted an IDE to Medtronic to study the DIAM in patients with low back pain caused by degenerative disc disease⁸¹. This is a randomized clinical trial comparing the DIAM Device for patients with low back pain caused by degenerative disc disease (DDD) at one level between L2 and L5 to non-surgical, conservative treatment. Patients enrolled in the study will be randomly assigned to receive either the investigational DIAM™ Device or non-surgical treatment that involves medication, physical therapy, patient education and spinal injections. Patients enrolled in the study must be evaluated by their surgeon at regular intervals. This study is one of three U.S. and European trials on the safety and effectiveness of the DIAM Spinal Stabilization System.

In October 2006, US FDA-regulated clinical trials for the Coflex were initiated for patients with spinal stenosis. Paradigm Spine received an Investigational Device Exemption ("IDE") from the FDA, to begin clinical trials for the Coflex. The study will involve 460 patients with lumbar spinal stenosis at up to 20 sites in a prospective randomized controlled study, comparing the Coflex device with pedicle-screw fusion.

7.5.1 ClinicalTrials.gov

A list of ongoing trials using interspinous devices or pedicle screw systems was retrieved on the ClinicalTrials.gov Website (Table 7.7).

Table 7.7. Identification of registered ongoing trials

Rank	Status	Study
1	Recruiting	IDE Clinical Trial Comparing Coflex vs. Fusion to Treat Lumbar Spinal Stenosis Condition: Lumbar Spinal Stenosis Interventions: Device: coflex; Procedure: fusion
2	Recruiting	Effects of X-STOP® Versus Laminectomy Study Condition: Lumbar Spinal Stenosis Interventions: Device: X-STOP®; Procedure: Laminectomy
3	Recruiting	Long-Term Outcomes for Lumbar Spinal Stenosis Patients Treated With X STOP® Condition: Lumbar Spinal Stenosis Intervention: Device: X STOP® Interspinous Process Decompression System
4	Recruiting	Treatment of Lumbar Spinal Stenosis; Comparison of Two Different Surgical Methods; Mini-Invasive Decompression to X-Stop Conditions: Lumbar Spinal Stenosis; Radiculopathy; Decompression, Surgical Interventions: Procedure: Minimal invasive decompression; Procedure: Interspinous Process Decompression (IPD)
5	Recruiting	Condition of Approval Study Condition: Lumbar Spinal Stenosis

		Intervention: Device: X-STOP PEEK IPD
6	Completed	Use of Radiostereometric Analysis (RSA) Following Spinal Fusion Versus the DYNESYS Stabilization System Conditions: Spinal Fusion; Orthopedic Procedures Intervention: Procedure: Radiostereometric Analysis beads inserted during surgery
7	Recruiting	Posterior Lateral Fusion (PLF) With Dynesys Condition: Spondylolisthesis
8	Terminated	Wallis Stabilization System for Low Back Pain Condition: Low Back Pain Interventions: Device: Interspinous process and dynamic stabilization (Wallis System); Device: Total Disc Replacement
9	Active, not recruiting	A Clinical Study of the Dynesys(R) Spinal System Conditions: Degenerative Spondylolisthesis or Retrolisthesis; Spinal Stenosis; Stenosing Lesion. Intervention: Device: Posterior Pedicle Screw System
10	Recruiting	Investigating Superion™ In Spinal Stenosis [ISISS] Conditions: Lumbar Spinal Stenosis; Neurogenic Intermittent Claudication Interventions: Device: Superion™ Interspinous Spacer; Device: X-STOP® IPD® Device
11	Active, not recruiting	Wallis Mechanical Normalization System for Low Back Pain Condition: Low Back Pain Interventions: Device: Interspinous process and dynamic stabilization; Device: Conservative Care
12	Recruiting	A Study of the In-Space Device for Treatment of Moderate Spinal Stenosis Condition: Spinal Stenosis Interventions: Device: Interspinous Spacer device; Device: Interspinous Process Distraction Device

7.5.2 Nederlands trial register

Another trial in recruiting phase was also identified in the trial registry in The Netherlands.

FELIX trial NTR1307	Recruiting	A randomised controlled trial, comparing Surgical Decompression with an Interspinous Implant in Patients with Intermittent Neurogenic Claudication caused by Lumbar Stenosis Condition : INC secondary to LSS Intervention: Device : Coflex Procedure: surgical decompression without fusion http://www.trialregister.nl/trialreg/admin/rctview.asp?TC=1307
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7.6 REPORTING OF ADVERSE EVENTS RELATED TO THE LUMBAR DYNAMIC STABILIZATION IMPLANTS TO THE BELGIAN MINISTRY OF PUBLIC HEALTH

7.6.1 Medical devices

In Belgium, Article 11 of the Royal Decree dated 17/03/2009 have modified the definition of a medical device proposed by Royal Decree dated 18/03/1999. Medical device is defined as any instrument, device, equipment, software, material or other article, used on its own or jointly, including software intended by the manufacturer to be specifically used for diagnostic and/or therapeutic aims, and required for it to function correctly, which is intended by the manufacturer to be used on humans for the following purposes :

- for diagnostic, prevention, control, treating or diminishing an illness,
- for diagnostic, control, treating, for diminishing or compensating an injury or handicap,
- for studying, replacing or modifying part of the anatomy or a physiological process,
- for mastering conception,

and whose principal intended action in or on the human body is not obtained by pharmacological or immunological means or by metabolism but whose function can be assisted in such a way.

7.6.2 European and Belgian Legislation about medical devices and notification of adverse events

There are three main European directives about the different categories of medical devices. They have been transposed into Belgian legislation. Each Member State designates the competent authority for each directive. In Belgium, The Federal Agency for Medicines and Health Products (FAMHP) is the competent authority for the directives 90/385/ECC (active implantable medical devices) and 93/42/EEC (medical devices). The competent authority for in vitro diagnostic medical devices (Directive 98/79/EEC) is the Scientific Institute for Public Health, section Biologie Clinique/ afdeling Klinische Biologie”.

The most important task of the competent authorities is market surveillance. In particular it must check the following operations :

- advise about the market launch of medical equipment,
- advise about exporters and distributors,
- advise about clinical studies with medical equipment that are conducted on Belgian territory,
- advise about incidents that occurred with medical equipment when on Belgian territory,
- advise about and watch over Belgian identified organisms.

The purpose of materiovigilance is to study and follow incidents that might result from using medical devices. It enables dangerous devices to be withdrawn from the market and to eliminate faults in medical devices with the intention of constantly improving the quality of devices and providing patients and users with increased safety.

Article 11 of the Royal Decree dated 18/03/1999 concerning medical devices describes the measures to be taken in the event of accidents taking place on Belgian territory. In particular, have to be notified:

- any dysfunction or any change of the characteristics and/or performance of a device, and any inadequacy in the labelling or instructions, which might lead to or have led to death or serious relapse in the state of health of a patient, a user or a third party.
- any technical or medical reason related to the characteristics or performance of a device for reasons shown in the previous paragraph and having led to the systematic withdrawal from the market by a manufacturer of devices of the same type.

Not only must one notify serious incidents which have actually taken place but also the cases where there was a risk of a serious incident but that incident was avoided thanks to the attention and action of the relevant people.

An incident is considered serious if it has one of the following consequences or could have had such a consequence:

- death, an illness or a handicap
- a permanent lesion of a function or structure
- the need for a medical or surgical operation
- the need for a prolongation of a surgical operation
- incorrect results of examinations leading to an incorrect diagnostic or treatment

Not only the manufacturers or their representatives should notify but also persons distributing devices, notified bodies, practitioners and people responsible for receiving and/or delivering devices should all signal incidents to : Federal Agency for Medicines and Health Products – Department Medical Devices. Incidents must be notified as quickly as possible using the quickest means possible. Incidents that have led to death or serious injury must be notified immediately.

7.6.3 Notification of adverse events in Belgium

Despite this mandatory rule, Federal Agency for Medicines and Health Products can not certify that the number of notifications exactly represent the true number of incidents. Moreover, causes of incidents are diverse and do not always concern the manufacturer or the device itself. For example, an inappropriate storage, a misplacement by a surgeon, a misuse by a healthcare professional or by the patient himself can induce an incident.

Since January 2005, three notifications were reported to the Federal Agency for Medicines and Health Products concerning interspinous implants (Table 7.8). All three concerned patients having loosed their implant going posteriorly. Ten notifications were reported concerning pedicle screws that have a more diverse origin (Table 7.9).

Table 7.8. Notifications concerning interspinous implants

Date	Description	Manufacturer's conclusion
02/2008	Patient has a loosen device going posteriorly	The conclusion of the investigation is the following: posterior loosening may occur if one of the clips is improperly snapped onto the spacer, if the band is partially cut with the scalpel when the excess band is removed, or if the spacer is not positioned sufficiently anterior, abutting the laminae.
02/2008	Patient has a loosen device going posteriorly	The X-Ray shows a spondylolsthesis whereas the implanted device is contraindicated for spondylolisthesis
02/2008	Patient has a loosen device going posteriorly	X-Ray shows a resorption of the spinous process (appears to have occurred progressively). Hypothetical factors contributing to this in include greater than usual bone remodeling activity, and possibly an initial bone lesion by the band passer

Source: personal communication from the Federal Agency for Medicines and Health Products (July 2009)

Table 7.9. Notifications concerning pedicle screws

Date	Description	Manufacturer's conclusion
01/2007	Packaging problem	The error had occurred in the source code of the printing software
07/2007	Loosening, Pain In vivo time: 3 years, 5 months Revision surgery needed	Unknown
07/2007	Pain Revision surgery needed	Unknown
10/2007	Loosening.	Unknown
12/2007	Infection revision surgery is scheduled	Unknown
04/2008	The device was implanted as a hybrid construction on L4-L5-S1 with cages between L5-S1. Returned screws are those of S1 because the segment was fused and the instrumentation was painful for the patient.	Unknown
05/2008	The system was revised due to back pain, no leg pain. The CT-Imaging of the screws showed a possible screw loosening.	Unknown
05/2008	Pain implant period : 7 months revision surgery due to pain	Describing the damage caused by revision surgery
09/2008	A screw was loose	Unknown

Source: personal communication from the Federal Agency for Medicines and Health Products (July 2009)

However, it is impossible to report an incident ratio, since the total number of devices implanted in Belgium is unknown.

8 ECONOMIC LITERATURE REVIEW

8.1 INTRODUCTION

Before a decision on the reimbursement of lumbar non-fusion posterior dynamic stabilization implants is taken, information on their cost and cost-effectiveness is needed to determine whether these devices offer 'value for money'. In this chapter, we reviewed the literature on economic evaluations of lumbar non-fusion dynamic stabilization implants.

8.2 METHODS

8.2.1 Literature search strategy

The following electronic databases were searched:

- MEDLINE (Ovid access), EMBASE, Psycinfo (Ovid access), Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials, Database of Abstracts of Reviews of Effects (DARE) and Health Technology Assessment (HTA) database (Cochrane Library)
- Econlit (Ovid access) and the NHS Economic Evaluation Database (NHS EED) (Cochrane Library)

Moreover, the bibliography of included studies was also scrutinized for further potential references.

The keywords used for the search and the results are detailed in the appendix 6.

8.2.2 Selection criteria and method

Every economic study designs were eligible for inclusion⁸²:

- Full economic evaluations which compare both cost and outcomes of at least two interventions and allow to calculate an incremental cost-effectiveness ratio (cost-effectiveness analyses, cost-utility analyses, cost-benefit analyses, cost-minimisation analyses);
- Cost-outcome comparisons which compare both cost and outcomes of at least two interventions but which do not allow to calculate an incremental cost-effectiveness ratio (e.g. different time frame);
- Cost comparisons which only compare the cost of at least two interventions;
- Cost-outcome descriptions which examine cost and outcomes of one intervention;
- Cost descriptions which only examine the cost of one intervention.

Systematic reviews of economic evaluations were also included.

No language restriction was applied. A first selection was based on titles and abstracts. Two researchers (SG-SS) assessed abstracts for relevance. Full papers were obtained and assessed for all studies considered as potentially relevant during this first selection step.

8.2.3 Data extraction and quality assessment strategies

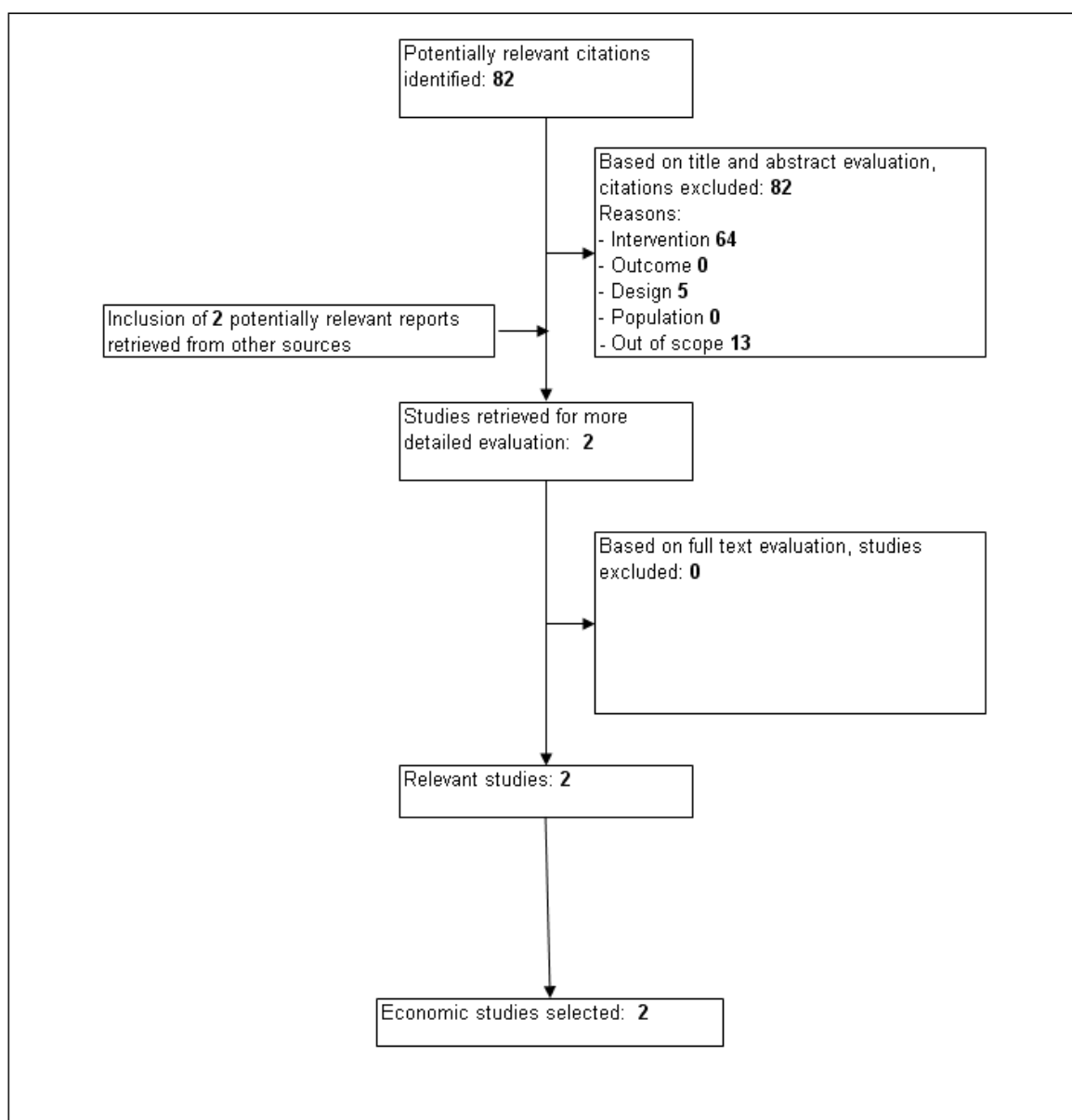
An economist (SG) extracted data and assessed study quality using a structured frame and a standard quality assessment checklist for economic evaluations based on the check list of the British Medical Journal⁸³ (appendixes 7 and 8). No quality rating was calculated and the quality of the studies was discussed narratively.

8.3 RESULTS

8.3.1 Researches available

Two references were retained (see Figure 8.1. for details). The first study, a cost-outcome comparison (Kondrashov et al. 2007)⁸⁴, was not retrieved through our research strategy on economic studies described above but was identified from a non systematic grey literature research via Google. This study came from an online journal not recorded in the analyzed databases. Abstracts of this study were also presented in congresses and in a book on “non fusion technologies in spine surgery”⁸⁵. The second study, a cost-minimisation analysis (MSAC 2007)³⁵ was identified from the literature research on HTA reports (see chapter 6). This study was not retrieved through our research strategy on economic studies because in this study, no keyword related to cost data was highlighted.

Figure 8.1. Economic literature search results flow chart



8.3.2 Data analyses and synthesis

8.3.2.1 *The study of Kondrashov et al.*⁸⁴

Study design and objectives

Kondrashov et al. (2007) conducted a retrospective cost-outcome comparison nested in the study by Zucherman et al.⁵³ (see paragraph 7.4.1.). They aimed at comparing the clinical effectiveness and direct hospital costs incurred by the X STOP implant versus decompression surgery (laminectomy, hemilaminectomy, laminotomy, or foraminotomy, alone or in combination) in patients with lumbar spinal stenosis (LSS), in one hospital.

In both groups, only patients fulfilling the following criteria were selected: availability of the preoperative Oswestry Disability Index (ODI) data, and willingness and ability to provide informed consent and to complete a postoperative ODI questionnaire. In the X STOP group, four patients were not included because of a lack of preoperative ODI data, and one patient has died prior the initiation of the study (unrelated cause). In the decompression surgery group, 17 patients met eligibility criteria but among these patients, 4 patients refused to participate and data were incomplete for 1 patient. Finally, 18 patients were identified in the X STOP group and 12 patients in the decompression surgery group.

Patients in the X STOP group were treated under local anaesthesia on an outpatient basis while patients in the decompression surgery group were treated under general anaesthesia on an inpatient basis.

The primary clinical outcome was the percentage of successful procedure for a four-year period, defined as an ODI improvement of at least 15 points. For cost calculation, Kondrashov et al. (2007) only assessed direct health care hospital costs. Long term costs and indirect costs were not measured.

Data collection and interpretation of results: Non-fusion interspinous spacer devices (X STOP) without decompression surgery compared to decompression surgery alone⁸⁴

Preoperative ODI data and costs data of the 30 selected patients were retrospectively assessed from the patients records.

The study highlighted that the success rate of the intervention was significantly higher in the X STOP group (78%) than in the decompression surgery group (33%) after four years ($p=0.02$).

Hospitalization costs were significantly higher in the decompression surgery group than in the X STOP group (incremental cost for 1 level: \$29 322; $p<0.001$; incremental cost for 2 levels: \$21 134; $p<0.001$). This difference was mainly explained by lower operative time ($p=0.002$) and lower length of stays ($p<0.001$) due to the use of local anaesthesia for the X STOP group on an outpatient basis instead of general anaesthesia. Because of different time frame between cost and outcomes, no incremental cost-effectiveness ratio (ICER) could be assessed.

Discussion

Because of an important number of limitations, these results should be interpreted with caution. The first limitation concerned the retrospective study design, which increases the risk of selection bias. Authors also specified that some patients had multiple comorbidities but no details were given and no comparison between groups was done, i.e. the evenly distribution of comorbidities among groups is unknown.

The sample size was also relatively small. Only 30 patients were analyzed (18 patients in the X STOP group and 12 in the decompression surgery group). Moreover, the successful procedure defined as an ODI improvement of at least 15 points was not statistically nor clinically justified and final outcomes such as the number of life years gained or quality-adjusted life years gained as advised in the pharmacoeconomic guidelines⁸⁶ were not measured.

The external validity of the cost difference is also at stake as it was mainly due to the fact that the X STOP procedure was performed under local anaesthesia on an outpatient basis. In contrast, in Belgium and Europe, the X STOP devices are usually implanted under general anaesthesia on an inpatient basis, according to the external experts who reviewed this KCE report.

Finally, even if patients were followed up during a four-year period, long term costs (including complications related costs) were not assessed. Data on re-operation rates or use of analgesics and their related costs were for example not reported.

8.3.2.2 *The study of the Medical Services Advisory Committee (MSAC)*³⁵

Study design and objectives

The Medical Services Advisory Committee (MSAC) assumed that the use of non-fusion dynamic stabilization implant was as safe as and no less effective than their main comparators (i.e. decompression surgery and fusion surgery). Therefore, the panel only conducted a cost-minimisation analysis. The analysis was performed for patients with symptomatic lumbar spine degenerative syndromes (i.e. lumbar spinal stenosis, herniated disc, degenerative spondylolisthesis, and facet joint osteoarthritis) in a health care payer perspective. Four strategies were compared:

- decompression surgery with the insertion of a non-fusion interspinous spacer device (i.e. Wallis, DIAM, Coflex, or X STOP);
- decompression surgery with the insertion of non-fusion pedicle screw device (i.e. Dynesys);
- decompression surgery alone;
- decompression surgery with fusion.

Fusion surgery without decompression and the use of non-fusion spinal dynamic stabilization implants without decompression were not analyzed. Only direct health care hospitalization costs were assessed. Indirect costs (such as productivity losses) and long term consequences were not assessed.

Each patient underwent laminectomy at 1 level or more. Authors assumed that only one level was treated in 65% of patients, two levels in 20% of patients, three levels in 10% of patients and four levels in 5% of patients. These estimates were based on a combination of two items in use in Medicare databases and the number of levels treated in the non-fusion literature. All patients underwent rhizolysis as part of the decompression surgery.

For fusion, 30% of patients received bone graft substitute and bone morphogenetic proteins and in 26% of patients a cage was used. These estimates were based on the distribution found in the Australian Medicare databases and on the literature research on non-fusion devices.

Data collection and interpretation of results: Non-fusion interspinous spacer devices with decompression surgery compared to decompression surgery alone³⁵

Procedures using non-fusion interspinous spacer devices could not be estimated because no specific corresponding code exists in the investigated database (Medicare Australia). Therefore, to estimate practitioner fees for surgery, they used a proxy estimates (i.e. "simple internal fixation of spine"). The estimate for inserting the spacer (i.e. \$122 in the calculations) was minor compared to the cost of decompression surgery and thus had little impact on the total cost.

For other hospital and accommodation fees, authors assumed that estimates were equal for both strategies. This cost was estimated using the proxy "Other back and Neck procedures", which is not specific to decompression surgery.

For surgery using non-fusion interspinous spacer devices, the only cost which was not based on proxy estimates or assumptions was the cost of the implant itself. Because of these assumptions, the cost difference between the strategies (i.e. \$7 193) was mainly explained by the cost of the implant (i.e. \$7 047).

Data collection and interpretation of results: Non-fusion with pedicle screw system and decompression surgery compared to fusion with decompression surgery³⁵

To identify procedure with non-fusion pedicle screw devices, no specific code exists. Therefore, to assess medical practitioner fees for surgery, the Panel used the same estimates than for fusion (“internal fixation 1 or 2 levels” and “internal fixation 3 or 4 levels”).

For other hospital and accommodation fees, the cost of both strategies was assumed to be equal. In these assumptions, the cost difference between the strategies (i.e. \$3 957) was mainly explained by the use of bone graft and cages in the strategy of decompression and fusion.

Discussion

Results were based on a lot of proxies and assumptions, no sensitivity analysis was performed and confidence intervals of results were not reported. Moreover, according to our literature research, the assumption that ‘the use of non-fusion dynamic stabilization implant was as safe as and no less effective than its main comparators’ was not supported by good quality evidence. Consequently, no conclusion can be drawn from this study.

Key points

Currently, there is insufficient evidence to draw conclusions about the relative cost-effectiveness of non fusion lumbar dynamic stabilization implants. More reliable cost and effectiveness data from the Belgian setting are needed, especially related on:

- the operative time;
- the length of stay;
- the short term complications rate;
- the long term complications and re-hospitalizations rate;
- QALYs

9 INTERNATIONAL COMPARISON

9.1 INTRODUCTION AND METHODS

The purpose of this chapter was to compare prices and reimbursement practices relating to non fusion dynamic stabilization implants among sampled European countries in order to have an overview of their cost for health insurers.

France, the Netherlands, Germany, Switzerland, and UK were selected because of their geographic proximity with Belgium and their comparable living standard.

Reimbursement information was obtained from national official websites related to health care and contacts with national official organisms. The reimbursement of these implants in the private sector was not analyzed in this report.

For price comparisons, the four mainly used non fusion dynamic stabilization implants in Belgium were selected, i.e. X STOP, DIAM, Wallis, and Dynesys (source: personal communication with the NIHDI). The price of Dynesys was calculated for one level, including 4 pedicle screws, 2 spacers, and 2 cords.

Price information came from contact with manufacturers (i.e. Zimmer and Medtronic). Currently, pricing of spinal implant is free in Belgium. Belgian prices described in this study are therefore the official market prices as reported by the manufacturers to NIHDI but manufacturers are free, for instance, to give larger discount to high-volume hospitals.

Manufacturers provided us the 2009 prices of each implant for all selected countries. For X STOP and DIAM, only mean prices and standard deviations could be published for confidentiality reason. For Switzerland and UK, prices were converted in Euro using the exchange rates on a monthly basis for April 2009 (source Eurostat), i.e. 0.89756 and 1.5147 respectively. Comparisons were made with and without inclusion of value added tax in the following way:

$$C_1 = \frac{price_{BE} - average(price_{FG})}{price_{BE}}$$

$$C_2 = \frac{price_{BE+VAT} - average(price_{FG+VAT})}{price_{BE+VAT}}$$

Where

$price_{BE}$ = price of the product in Belgium excluding value added tax (VAT) (in €2009)

$price_{FG}$ = price of the product in the foreign country excluding VAT (in €2009)

$price_{BE+VAT}$ = price of the product in Belgium including VAT (in €2009)

$price_{FG+VAT}$ = price of the product in the foreign country including VAT (in €2009)

$average$ = average price for selected foreign countries (in €2009)

A positive result means that the product is on average more expensive in Belgium. Conversely, a negative result indicates that the product is on average cheaper in Belgium. The amount indicates how much the average price abroad is different compared to the Belgian price, as a percentage. To have an idea on price variation among the selected foreign countries, the standard deviation was also specified.

In a second step, the difference in overall price levels between countries was eliminated to allow for differences in general purchasing power between countries. Comparative price levels published by the OECD for April 2009 were used for these calculations.

These comparative price levels are defined as the ratios of purchasing power parities to exchange rates⁸⁷.

$$C_3 = \frac{\text{price}_{BE+VAT} - \text{average} \left(\text{price}_{FG+VAT} * \frac{CPL_{BE+VAT}}{CPL_{FG+VAT}} \right)}{\text{price}_{BE+VAT}}$$

price_{BE+VAT} = price of the product in Belgium including VAT (in €2009)

price_{FG+VAT} = price of the product in the foreign country including VAT (in €2009)

CPL_{BE+VAT} = comparative price level for Belgium (=100, Belgium as basis)

CPL_{FG+VAT} = foreign comparative price level^d

average = average price for selected foreign countries

Calculations were rounded down to integer values.

9.2 REIMBURSEMENT PRACTICES COMPARISON

9.2.1 Belgium

The reimbursement of implants in Belgium is linked to the articles 28 and 35 of the health care nomenclature. The article 28 was created in 1984. Then, the article 35 which proposes a new nomenclature of implants was set up. The transfer of the article 28 toward the article 35 is progressive^{88,89}. Currently, neither non fusion interspinous implants nor non fusion pedicle screw implants are officially reimbursed in Belgium. However, in practice, pedicle screw implants are partially reimbursed because some elements of the implant (the cords and pedicle screws) correspond to nomenclature codes of the article 28 (see Table 9.1). Nevertheless, when the transfer of the article 28 toward the article 35 will be complete, spinal implants could only be reimbursed if they are placed on a limitative list approved by the Assurance Committee. The limitative list concerning spinal implant is currently in progress. Once this list will be set up, a maximum end-user price for the implants will probably be determined (sources: communication with NIHDI)⁸⁸.

^d 100 in France, 96 in Germany, 97 in the Netherlands, 127 in Switzerland and 80 in UK

Table 9.1. Belgian nomenclature codes used in practice

Nomenclature code		Description	Reimbursement
638234	638245	Compound implant (pedicle screw, etc) «– Implant composé (implant d'ancrage unitaire (vis pédiculaire ou corporeale, broche filetée, crochet pédiculaire ou lamaire, agrafe ...) accompagné de toutes les pièces d'attache, d'ajustement, de réduction et de blocage de cet implant d'ancrage unitaire à l'implant principal) – Samengesteld implantaat (éénverankeringsimplantaat (gesteelde of corporeale schroef, stift met schroefdraad, gesteelde of lamaire haak, agrafe,...) met alle stukken voor vasthechten, aanpassing, repositie en blokkering van dit éénverankeringsimplantaat aan het hoofdimplantaat»	€309.85
Or 638116	638120	Screw «– Implant d'ancrage dans une hémi-vertèbre postérieure ou dans un corps vertébral. Implant simple : Vis (s'adresse aux vis spécifiquement conçues pour les ostéosynthèses vertébrales) – Verankeringsimplantaat in een achterste hemivertebra of in een wervellichaam Eenvoudig implantaat: Schroef (heeft betrekking op de schroeven die specifiek zijn onderworpen voor vertebrale osteosynthesen)»	€154.92
And 637991	638002	Synthetic ligament «– IMPLANT PRINCIPAL : Implant qui relie au moins deux niveaux vertébraux. Tige: Ligament synthétique – Implantaat dat ten minste twee wervelniveau's verbindt Schacht Synthetisch ligament»	€258.21

9.2.2 United Kingdom

In the UK, every legal resident is covered by the National Health Service (NHS). Except for some pharmaceutical prescriptions, optical and dental services charges, health services are provided freely by local NHS organizations.

Since 2004, a new reimbursement system for hospital care was set up, known as the "Payment by results" system. The volume of activity for the next calendar year is planned by negotiation contracts between primary care trusts and health care providers. Choices are based on guidelines provided by other national organizations such as the National Institute for Clinical Excellence⁹⁰.

Concerning the use of non fusion interspinous stabilization implants, NICE stated that even if there were no major safety concerns, evidence of efficacy was limited and was restricted to the short and medium term. Therefore, the Panel decided that these procedures should only be used in the context of "special arrangements for consent, audit and research"⁵⁶. The Panel also stressed that before using these devices, clinicians should take the following actions:

- "Inform the clinical governance leads in their Trusts.
- Ensure that patients understand that the procedure is not curative, and that further surgery may be needed. Patients should be provided with clear written information. In addition, use of the Institute's Information for the public is recommended (available from www.nice.org.uk/IPG165publicinfo).

- Audit and review clinical outcomes of all patients having interspinous distraction procedures for spinal stenosis causing neurogenic claudication in the lumbar spine⁵⁶.

The panel also analyzed non-rigid stabilization procedure for the treatment of low back pain, and especially the Dynesys and stated that "current evidence on the safety of these procedures is unclear and involves a variety of different devices and outcome measures. Therefore, these procedures should not be used without special arrangements for consent and for audit or research"⁴⁴. Same recommendations concerning the actions to perform before using these procedures were formulated (see above for interspinous implants).

Moreover, prices of inpatient and daycase activity are determined according to national tariffs for each Healthcare Resource Group (HRG). No distinction was done in tariffs between elective inpatient stays and daycases, giving a clear incentive for daycase where possible. The HRG process takes into account different factors such as primary and secondary procedures; primary, subsidiary and secondary diagnosis; age; sex; length of stay etc^{91,92}. In UK, specific procedure codes for both interspinous spacer and dynamic stabilization implant exist (see Table 9.2.)⁹³. They are thus, at least partially, taken into account in the reimbursed tariffs.

As mentioned in the method section, the reimbursement of these implants in the private sector was not analyzed in this report.

Table 9.2. Procedure codes in UK

CODES	DESCRIPTION
V281	INSERTION OF LUMBAR INTERSPINOUS PROCESS SPACER - PRIMARY INSERTION OF LUMBAR INTERSPINOUS PROCESS SPACER
V282	INSERTION OF LUMBAR INTERSPINOUS PROCESS SPACER -REVISIONAL INSERTION OF LUMBAR INTERSPINOUS PROCESS SPACER
V288	INSERTION OF LUMBAR INTERSPINOUS PROCESS SPACER -OTHER SPECIFIED
V289	INSERTION OF LUMBAR INTERSPINOUS PROCESS SPACER - UNSPECIFIED
V401	STABILISATION OF SPINE - NON-RIGID STABILISATION OF SPINE
V408	STABILISATION OF SPINE - OTHER SPECIFIED
V409	STABILISATION OF SPINE - UNSPECIFIED

9.2.3 Germany

In Germany, investments of hospitals are financed by the "Länder"^e and operating costs of hospitals (medical goods, personnel costs, etc.) are financed by the sickness funds (plus private insurers). Operating costs are covered by a budget negotiated in advance for one year with the Länder associations or representations of the sickness funds. Since 2003 optionally, since 2004 necessarily, the inpatient payment system was based on Diagnosis-Related Groups (DRG). The German DRG (G-DRG) system is applicable to all patients (members of the Statutory health insurance (SHI)^f, of private insurance or self-paying patients) and to all hospitals services (with the major exception of psychiatry, psychosomatic medicine, or psychotherapy services)⁹⁴. Compared with other countries, this system gives a great importance to the procedure used. The DRG is determined by the diagnosis, procedures, co-morbidity, clinical severity and patient age⁹⁵.

^e Germany is a federal republic composed of 16 states (=Bundesländer)

^f Representing 88% of patients in 2003 ⁹⁴

A relative weight for each DRG is determined on a national level. Then, the hospital-specific case-mix index is determined by the sum of all relative weight divided by the number of cases. The hospital reimbursement is then established by multiplying this case-mix by the “state-wide base rate” and by the number of cases to obtain. The state-wide base rate is negotiated in every “Bundesland”. In 2005, the negotiated state-wide base rate ranged from €2 585 to €3 000 with an average of €2 785⁹⁵.

Additional remuneration can also be obtained such as payments for new examination and treatment methods or for some complex services or pharmaceuticals (i.e. inter-current dialysis)⁹⁴.

No specific DRG for stabilization procedures using an interspinous implant exists but this intervention is usually attached to the DRG I56B, with a relative weight of 0.643 (in 2009). For a hypothetical state-wide base rate of €2 750, the reimbursed amount is therefore €1 768.25⁹⁶. According to the German Institute for Medical Documentation and Information (“Deutsches Institut für Medizinische Dokumentation und Information”), intervention with interspinous devices can also be attached to the DRG I56A, with a relative weight of 1.240 (in 2009). In this case, for a hypothetical state-wide base rate of €2 750, the reimbursed amount is therefore €3 410.

An additional remuneration can be obtained for these devices (ZE 2009-52), which usually varies from €800 to €2 000 per segment (negotiations between hospitals and sickness funds; source: Zimmer).

For non fusion pedicle screw systems, the reimbursement is subject to same conditions as a 360° fusion intervention (DRG I09B - relative weight of 3.245 in 2009). For a hypothetical state-wide base rate of €2750, the reimbursed amount is therefore €8 923.75⁹⁶.

For both procedures, clinical indications are described using the ICD-10-GM codes (see Table 9.3. and Table 9.4.).

It should be noticed that in the next year, the DRGs and the “ZEs” will change (it is a “self-learning” system.)

Table 9.3. German codes used for interspinous spacers

Codes	Description
DRG I56B:	Other interventions on the spine ... without ...ou implantation of an interspinous spacer “Andere Eingriffe an der Wirbelsäule ohne äußerst schwere CC, ohne komplexen Eingriff, ohne mäßig komplexen Eingriff oder Implantation eines interspinösen Spreizers“
DRG I56A:	Other interventions on the spine ... with moderately complex intervention “ Andere Eingriffe an der Wirbelsäule ohne äußerst schwere CC, ohne komplexen Eingriff, mit mäßig komplexem Eingriff“
ZE 2009-52	Implantation (or switch) of interspinous spacer “Implantation oder Wechsel eines interspinösen Spreizers“
ICD-10-GM: M42.96	Osteochondrosis of the spine, unspecified: lumbar area “Osteochondrose der Wirbelsäule, nicht näher bezeichnet: Lumbalbereich“
ICD-10-GM: M51.1	Damage of lumbar spine and other with radiculopathy. Sciatica through vertebral injury “Lumbale und sonstige Bandscheibenschäden mit Radikulopathie. Ischialgie durch Bandscheibenschaden“
ICD-10-GM: M51.2	Other specified intervertebral disc displacement. Lumbago for disc displacement “Sonstige näher bezeichnete Bandscheibenverlagerung Lumbago durch Bandscheibenverlagerung“

Table 9.4. German codes used for dynamic pedicle screw systems

Codes	Description
DRG I09B:	Spinal fusion with... or with implantation of a stabilization system with screw. “Wirbelkörperfusion mit äußerst schweren CC mit anderer Kyphoplastie oder mit schweren CC, ohne andere Kyphoplastie oder mit komplexer Kyphoplastie, allogener Knochentransplantation oder Implantation eines Schrauben-Stabsystems“
ICD-10-GM: M48.06	Spinal canal stenosis: Lumbar area “Spinalkanalstenose: Lumbalbereich“
ICD-10-GM: M43.16	Spondylolisthesis: Lumbar area “Spondylolisthesis: Lumbalbereich“

9.2.4 The Netherlands

In the Netherlands, a new private health insurance system with social conditions has been set up. Under the new Health Insurance Act (“Zorgverzekeringswet”), each resident is obliged to take out health insurance, insurers are obliged to accept each resident in their area of activity and a system of risk equalization has been set up to prevent risk selection⁹⁷.

A standard package of essential healthcare must be provided by all insurances. This package was determined by criteria such as demonstrable efficacy, cost-effectiveness, and the need for collective financing⁹⁷. For medical devices there are several arrangements. Non-implantable medical devices for outpatient use are in general included in a limitative list for which new categories can be added to the list each year on the advice of the College of Care Insurances (“College voor zorgverzekeringen” (CVZ)). Implantable medical devices and non-implantable medical devices that need supervision by a medical specialist fall under the open system for medical specialist care. To be included in the basic healthcare package, medical specialists care have to follow evidence-based medicine standards (‘stand van de wetenschap en praktijk’) or, in the absence of such standards, must be considered as reasonable and adequate care (‘verantwoorde en adequate zorg en diensten’) within the profession. In order to evaluate this, CVZ has developed an evaluation framework available on their site (http://www.cvz.nl/resources/rpt0711_stand-wetenschap-en-praktijk_tcm28-25006.pdf). The difference between an open system and a closed system is that they do not have to evaluate everything before it can enter the system. Currently, they only assess interventions for which there are doubts whether the intervention meets the 'evidence-based medicine standards'.

Non fusion interspinous stabilization implants and non fusion pedicle screw systems have been assessed by the CVZ and a negative judgment was rendered. These non fusion implants are therefore not included in the standard package of essential care. If health insurances decide to reimburse the implant/procedure after all it will have to be funded by additional insurance (complementary insurance)^{98, 99}.

9.2.5 Switzerland

In Switzerland, every legal resident is obliged to take out an individual health insurance. People can freely choose a public non-profit or a private insurer and insurers are obliged to accept every resident without condition or delay in their area of activity. Each public non profit insurer has to offer a mandatory basic insurance and has the opportunity to offer complementary insurances. This mandatory basic insurance covers a number of reimbursed services, devices, medicines, specialities and laboratory tests described in the law (limitative lists). If a health professional executes or prescribes a service which is not covered by the mandatory basic insurance, he is obliged to inform the patient^{100,101}. Procedures for non fusion interspinous devices or non fusion pedicle screw devices are currently included in the list of services reimbursed by the mandatory insurance in the following conditions:

- The physician has to be aggregated into the Switzerland society of spinal surgery, the Switzerland society of orthopaedic surgery, and the Switzerland society of neurosurgery.
- The services' provider must have a national register, coordinated by the Institute for evaluative research in orthopaedic surgery.

Therefore, both the procedures and the implants are currently reimbursed by public insurers but these procedures are currently under evaluation and reimbursement conditions are only valid until December, 10th 2010¹⁰⁰.

9.2.6 France

To be reimbursed, orthopaedic implantable medical devices without derived or tissue from biological origin must be included in the list of reimbursable products and services (LPP: "Liste des produits et prestations remboursables") and must be prescribed by a health professional¹⁰².

Registration of implants in this list is the responsibility of the Products and Services Assessment Committee of the French Agency for the Safety of Health Products. This committee examines the justification for registering or renewing the registration of implants and specifies the conditions for reimbursement. The registration in this list would depend of the service rendered by the product, assessed essentially by the therapeutic and technical effect of the product, the safety, the comparison with other available alternatives, the severity of the disease or handicap addressed by the product, and other public health considerations such as the impact on the quality of life. Devices are generally registered using a generic description.

The Economic Committee for Health Products of the Ministry of Health finalises conditions for reimbursement and determines the reimbursement tariff. Devices can only be reimbursed if they lead to an improvement in the service rendered or to cost savings¹⁰³. The public price of devices included in the LPP is limited to the LPP reimbursement tariffs.

Until now, no demand for the reimbursement of dynamic interspinous implants and non fusion pedicle screw systems was recorded. Therefore, no specific codes for these implants could be found in the LPP. However, the components of the implants could be considered separately by the generic descriptions presented in Table 9.5.¹⁰⁴. Only the X STOP device has no LPP tariff. The reimbursement of an intervention with the X STOP is therefore based on the "groupe homogène de séjour" (GHS) system of payment (no specific code for interspinous implants) covering the procedure and only partially the implant (personal communication with the National Health Insurance Fund for Salaried Workers (Caisse nationale d'assurance maladie des travailleurs salariés (CNAMTS)).

Table 9.5. Codes in the LPP used for interspinous devices and dynamic pedicle screw systems in France

Implant	Code	Description	Reimbursement tariff (= limited public price; VAT of 5.5% included)
DIAM	3115583 301E01.65	Spinal, pad. In the limit of two per procedure. « Rachis, coussinet. Dans la limite de 2 par intervention »	€46.04
	3104616	Artificial articular ligament of the spine. « Ligament articulaire artificiel du rachis, de remplacement ou de renfort »	€259.16
	3183633	Artificial articular ligament, fixation or setting system. « Ligament articulaire artificiel système de fixation ou de sertissage. Accessoires pour ligamentoplastie, système de fixation ou de sertissage, quel qu'en soit le type (dans la limite de €210.38 par intervention). Lorsque les ligaments sont livrés avec un système de fixation serti, ils sont pris en charge par addition des références 3145928, 3154347, 3114684, 3104616 ou 3183165 et de la référence 3183633 »	€70.13
Wallis	3187938 301E01.64	Metallic interspinous spacer. « Cale interépineuse métallique »	€46.04
	3104616	Artificial articular ligament of the spine. « Ligament articulaire artificiel du rachis, de remplacement ou de renfort »	€259.16
	3183633	Artificial articular ligament, fixation or setting system. « Ligament articulaire artificiel système de fixation ou de sertissage. Accessoires pour ligamentoplastie, système de fixation ou de sertissage, quel qu'en soit le type (dans la limite de €210.38 par intervention). Lorsque les ligaments sont livrés avec un système de fixation serti, ils sont pris en charge par addition des références 3145928, 3154347, 3114684, 3104616 ou 3183165 et de la référence 3183633 »	€70.13
Dynesys	3137283 301E01.613	Spine, anchorage implant, pedicle screw «Rachis, implant d'ancrage, vis pédiculaire. Vis spécifique du rachis de type pédiculaire, monoaxiale ou polyaxiale, avec système d'assemblage et de blocage»	€185.23
	3115583 301E01.65	Spinal, pad. In the limit of two per procedure. « Rachis, coussinet. Dans la limite de 2 par intervention »	€46.04
	3104616	Artificial articular ligament of the spine. « Ligament articulaire artificiel du rachis, de remplacement ou de renfort »	€259.16

9.3 PRICE COMPARISONS

9.3.1 Price comparison excluding VAT

Currently, pricing of spinal implant is free in most countries, except in France and in some cantons of Switzerland where prices are fixed by a list (i.e. the LPP in France; source: communication with Medtronic). Prices described in this section are the average market prices as reported by the manufacturers (i.e. Zimmer and Medtronic). Prices of the Wallis and the Dynesys excluding VAT are described for each country in Table 9.6. Mean prices and standard deviations for DIAM and X STOP are described in Table 9.7.

Table 9.7 showed that prices varied strongly across countries. Prices in France are lower than in other countries for historical reasons. As explained in the previous section, no specific reimbursement demand by trademarks was done but some of these implants (Wallis, DIAM, Dynesys) can be reimbursed elements by elements using generic descriptions in the LPP. The maximum tariffs determined by this list are thus based on a generic description that can be applied to other medical devices and that is not specific to these implants. Only the price of X STOP is free in France (not based on LPP tariffs). Prices in other countries are issued from negotiations and depend essentially of the sales volume in the country and of additional services which could be included in the prices (training of the physicians, replacement and repairs, urgent delivery, deposit, etc.)⁸⁹.

As shown in Table 9.7, Belgian prices excluding VAT were on average lower than in the other selected countries for DIAM and Wallis and higher for X STOP and Dynesys.

Table 9.6. Prices per country (excluding VAT)

	Germany	Switzerland	France	UK	The Netherlands	Belgium
Wallis	€900-1 250*	€1 400-1 600*	€810	€1 800	€825	€1 061
Dynesys	€1 945	€2 860	€1 244	€2 239	€2 794	€2 380

Source: manufacturer (i.e. Zimmer). *Mean used in calculations: €1 075 and €1 500.

Table 9.7. Mean prices excluding VAT

	Belgium	Mean of prices used in 5 foreign countries	SD	C ₁
DIAM	1 500 €	1 562 €	591 €	-62 €
X-STOP	2 375 €	2 284 €	219 €	91 €
Wallis	1 061 €	1 202 €	435 €	-141 €
Dynesys	2 380 €	2 194 €	666 €	186 €

Sources: manufacturers (i.e. Zimmer and Medtronic) – Own calculation

9.3.2 Price comparison including VAT

The VAT rate on implants is 6% in Belgium and is usually higher in other countries⁸. In France, implants with tariffs of the LPP had a VAT rate of 5.5% while other implants (X STOP) had a VAT rate of 19.6%. Because of higher VAT rates in other countries, the price of X STOP including VAT becomes on average less expensive in Belgium. Only Dynesys remains on average more expensive (see Table 9.8).

⁸ 15% in UK; 7% in Germany; 7.6% in Switzerland; 5.5-19% in France; 6-19% in the Netherlands

Table 9.8. Mean prices including VAT

	Belgium	Mean of prices used in 5 foreign countries	SD	C ₂
DIAM	1 590 €	1 693 €	637 €	-103 €
X-STOP	2 518 €	2 595 €	281 €	-77 €
Wallis	1 125 €	1 313 €	522 €	-188 €
Dynesys	2 523 €	2 375 €	717 €	148 €

Sources: manufacturers (i.e. Zimmer and Medtronic) – Own calculation

9.3.3 Price comparison using comparative price level

By eliminating the difference in price level between countries, Belgian prices for DIAM, X-STOP and Wallis are yet less expensive compared to the mean price of the other selected countries. Dynesys is always on average more expensive in Belgium (See Table 9.9). It should also be noted that without the inclusion of the prices in France (particularly cheap), the price of Dynesys would be on average cheaper than in other countries.

Table 9.9. Mean prices including VAT, obtained by eliminating the difference in price level between countries

	Belgium	Mean of prices used in 5 foreign countries	SD	C ₃
DIAM	1 590 €	1 741 €	746 €	-151 €
X-STOP	2 518 €	2 634 €	372 €	-116 €
Wallis	1 125 €	1 363 €	708 €	-238 €
Dynesys	2 523 €	2 403 €	724 €	120 €

Sources: manufacturers (i.e. Zimmer and Medtronic) – Own calculation

Key points

The coverage of the implant varies across countries and different reimbursement mechanisms exist:

- Use of a “HRG” system of payment (similar to a DRG system) with specific procedure codes that globally covers the procedure and the implant (UK)
- Use of a limitative list of services that covers the procedure and the implant (Switzerland)
- Use of a non specific “DRG” that covers the procedure and use of a limitative list that covers the implant (France)
- Use of a non specific “DRG” that covers the procedure and additional amount for the implant (Germany)
- Use of a non specific “DRG” that covers the procedure and partially the implant (France, Germany, Belgium)
- No mandatory reimbursement (The Netherlands)

Compared to selected countries, prices of the implants vary strongly across countries and are on average cheaper in Belgium (except for the Dynesys). In France, tariffs of implants determined by the LPP are particularly cheap (for historical reason).

10 CONCLUSIONS

10.1 CLINICAL EFFECTIVENESS AND SAFETY

Studies retrieved for assessing the effectiveness and safety of dynamic stabilization implants of the lumbar spine (interspinous implants and pedicle screws) were generally of low quality due to lack of randomisation, short or medium follow-up, lack of comparator, small sample sizes, mix of interventions and mix of clinical indications. A lack of high quality RCTs comparing dynamic stabilization devices with an adequate comparator in large sample sizes and with a long-term follow-up hampers firm conclusions about the efficacy of such devices.

Only studies about X STOP, Wallis and Dynesys corresponding to our inclusion criteria were retrieved. Other devices such as DIAM and Coflex were not analyzed in this report due to a lack of good quality studies.

The RCT⁵³ which results led to the FDA approval of the X STOP and referenced by most authors of subsequent studies was of questionable quality. In its review for the premarket approval (PMA) of the X STOP, the Center for Devices and Radiological Health (CDRH) of the FDA already underlined most of the methodological flaws of this RCT. In spite of bias induced by the methodology, the PMA was approved. Moreover, at 24 months post-intervention, a proportion of patients whose symptoms had improved at 6 and 12 months tended to experience a return of their symptoms to baseline levels, an observation that put the long-term efficacy of the device at stake. Subsequent studies using a control group^{58,59} were follow-up studies of the original RCT⁵³ and were conducted by the same researchers who are also the inventors of the device. Therefore, they suffered from the same methodological bias. A long-term follow-up (five years) on adverse events as well as pain and function evaluations, using the same questionnaires as in preoperative setting (ODI, VAS and ZCQ), was requested post-approval.

In conclusion, there is a very low level of evidence supporting the use of interspinous devices for degenerative spinal disease. It relies on one RCT with important limitations and on some uncontrolled before-and-after studies, sharing the same limitations (short- or medium follow-up, lack of comparator, small sample sizes and mix of clinical indications). Moreover, current evidence on the safety of these procedures remains unclear. There is concern about recurrent pain in the operated and adjacent levels, device migration, and potential infection.

The Dynesys system was granted a FDA 510(k). This type of approval does not involve extensive clinical trial data submission and review by the FDA^h. Moreover, while the Dynesys system was conceived as a pedicle-based dynamic device, paradoxically it was approved as an adjunct to fusion by the FDA.

While the indications for Dynesys mentioned in the FDA approval covered degenerative spondylolisthesis with objective evidence of neurologic impairment and failed previous fusion (pseudarthrosis), all included studies in our report considered Dynesys without fusion for a mix of clinical indications including spinal stenosis. This lack of specific clinical indications and application blurs the device evaluation. On 31 August 2004, the Orthopaedic and Rehabilitation Devices Panel (FDA) recommended to identify the patient population that is most likely to benefit from the Dynesys device, noting that overall effectiveness was not demonstrated in a majority of the clinical study population. The panel also cited concerns with the longer-term effectiveness of the device (longer than 2 years). Moreover, the Dynesys placement procedure was always undertaken concurrently with disc decompression or discectomy. It is therefore difficult to determine the clinical benefit derived directly from the implant.

^h In order to qualify for a 510(k) clearance, it must be demonstrated that the new device is similar in function to a device already approved by FDA for interstate commerce prior to May 28, 1976.

An IDE study for a non fusion application is currently going on in the United States. Patient enrolment has been completed.

In general, dynamic stabilization systems represent an option for patients that would otherwise undergo fusion procedures. As with any spinal care treatment, there are concerns associated with long-term performance. As a principle of their action, the use of posterior stabilization implants may induce kyphosis at the operative level. The major concern is that creating kyphosis at the affected level will increase potential for hyperextension at the adjacent levels. Another concern, particularly for devices that block extension by bearing load on the spinous processes, is the potential for progressive bony erosion resulting in a loss in effectiveness and an increased potential for bone fractures. This may be problematic as the indications for use of such devices is generally segmental stenosis that often occurs at the age when osteoporosis is also a factor⁴³.

Current evidence on the safety of these procedures remains unclear. Malpositioned or broken screws leading to nerve root damage, failure of the bone/implant interface and failure to control pain have all been reported events.

Given this poor quality of evidence; given the fact that information on long-term results and adverse events (i.e. exceeding 2 years) of this procedure is still insufficient (interspinous devices) or lacking (pedicle screws); given the high failure rate recorded through various studies; given the fact that there is insufficient information on the prevention of adjacent level disease, and on the clinical outcomes after revision or conversion surgery; and given the fact that numerous RCTs are ongoing, interspinous devices as well as pedicle screw based devices have to be considered an experimental procedure for the time being. To draw sound conclusions that a posterior dynamic device is better than decompressive surgery (for interspinous devices) or better than fusion (for pedicle screw devices), results from multiple, similarly designed, independently funded trials must be compiled, compared, and contrasted¹⁰⁵. A limitative list of clinical indications established in consensus by neurosurgeons has to be set up. Since this is still an emerging technology and a learning curve can be expected, the technique should be performed by a well-trained and experienced team in few centres that already record high volumes of lumbar surgical interventions. Training in this technique and a strict adherence to the manufacturers' instructions is needed to reach an appropriate level of expertise in the procedure. Additionally to self-reported questionnaires, objective outcomes have to be assessed (such as walking distance, going upstairs, return to work, sick leave).

This conclusion is in line with other HTA Agencies^{35,56} that also adopted a careful position towards lumbar non-fusion posterior stabilization devices. NICE recommended that these procedures should not be used without special conditions for fully-informed patient consent and for audit or research. In the same way, MSAC recognized that there is insufficient evidence to recommend a change in the public funding arrangements for both devices at this time.

10.2 ECONOMIC CONCLUSIONS

Only one cost-minimisation analysis and one cost-outcome comparison were identified from the literature review and the quality of these studies was insufficient to draw any evidence-based conclusions.

The study of Kondrashov et al. showed that the non fusion interspinous spacer "X STOP" without decompression seemed to be a cost-saving strategy compared to decompression surgery because of a lower operative time and a shorter hospitalization length. However, this result was mainly due to the fact that every patient in the X STOP group was treated under local anaesthesia on an outpatient basis, which is usually not the practice in our country (general anaesthesia). Moreover, data were collected from a retrospective study with a low level of quality.

The MSAC study was a retrospective cost-minimisation analysis performed through Medicare databases. However, patients with non fusion dynamic stabilization implants could not be identified from these databases. The analysis was therefore mainly based on proxies and assumptions.

The long term impact of non fusion lumbar dynamic stabilization implants on a final outcome such as the quality-adjusted life-year (QALY) and long term costs due to complications and re-hospitalizations were not measured in these two studies.

In conclusion, the impact of non fusion lumbar dynamic stabilization implants on the hospitalization length, operative time, short and long term complications (including re-hospitalizations rates), and on QALYs is unknown from the Belgian setting.

Moreover, given the lack of evidence on clinical effectiveness of interspinous implants and pedicle screw based systems for the treatment of symptomatic lumbar spinal stenosis or degenerative spondylolisthesis, no credible cost-effectiveness analysis can be performed.

Finally, given the lack of data about the prevalence of these affections (clinical indications) and given the lack of data about frequency of surgical interventions for decompression and stabilization (dynamic stabilization or fusion) of lumbar spine, it is impossible to estimate the budget impact of a hypothetical reimbursement of these new surgical technologies for our country.

10.3 INTERNATIONAL COMPARISON

Analysis of the sample of neighbouring countries shows that the coverage of the implants varies among countries.

In UK, the implant is globally covered by the “HRG” system of payment, using specific procedures codes for these implants.

Some other countries have limitative lists of mandatory reimbursed services (The Netherlands and Switzerland). In Switzerland, the surgical procedures for these implants are included in the list while not in the Netherlands. In the Netherlands, the reimbursement of the procedure and of the implant is therefore not mandatory.

The procedure is also sometimes covered by the “DRG” system of payment and a supplementary amount is reimbursed for the implant (e.g. Germany and France). In France, the implant must be included in the limitative list of reimbursed product and services (LPP) and have a LPP tariff for reimbursement otherwise the implant is only partially covered by the procedure.

Then, in some cases, only the procedure is covered but not the implant (or only partially), such as in Belgium.

Finally, only Germany has described clinical indications using ICD-10-GM codes. Reimbursement procedures and conditions in each country are summarized in Table 10.1 and Table 10.2.

Table 10.1. Reimbursement of interspinous devices

Country	Reimbursement of the implant	Conditions
Belgium	No specific reimbursement	/
UK	Covered by the "HRG" system of payment (with specific procedure code)	Negotiation and "special arrangements for consent, audit and research"
Germany	Covered by the "G-DRG" system of payment (no specific procedure code) + additional coverage (depending of negotiation)	Specific diagnosis codes: Osteochondrosis of the spine - lumbar area; Damage of lumbar spine and other with radiculopathy - Sciatica through vertebral injury; Other specified intervertebral disc displacement - Lumbago for disc displacement)
The Netherlands	No mandatory reimbursement, depending of the insurer	/
Switzerland	Yes, included in the list of services reimbursed by the mandatory insurance	-Performed by an aggregated physician -Inclusion in the national register
France	Covered by the "GHS" system of payment (no specific procedure code) + additional amount if included in the list of product and services (LPP) = LPP tariffs Wallis, DIAM: LPP tariffs for each element X STOP: no LPP tariffs	Included in the LPP and prescribed by a physician

Table 10.2. Reimbursement of dynamic pedicle screw systems

Country	Reimbursement of the implant	Conditions
Belgium	In practice, partially reimbursed	In the future, possible inclusion in a limitative list
UK	Covered by the "HRG" system of payment with specific procedure codes	Negotiation and "special arrangements for consent, audit and research"
Germany	Covered by the "G-DRG" system of payment (no specific procedure code: fusion)	Specific diagnosis codes: Spinal canal stenosis and spondylolisthesis
The Netherlands	No mandatory reimbursement, depending of the insurer	/
Switzerland	Yes, included in the list of services reimbursed by the mandatory insurance	-Performed by an aggregated physician -Inclusion in the national register
France	Covered by the "GHS" system of payment (no specific procedure code) + additional amount if included in the list of product and services (LPP) = LPP tariffs Dynesys: LPP tariffs for each element	Included in the LPP and prescribed by a physician

Concerning the implant prices, only the Dynesys was on average more expensive in Belgium than in other countries. Important variations across countries were found. In France for instance, prices of implants determined by the LPP tariffs were especially cheap compared to other countries. However, these tariffs were not representative of the implant value because they are determined using generic descriptions for each component and these generic descriptions can be used for other medical devices (no specific description). Other variations result from negotiations and depend essentially of the sales volume in the country and of the services included in the price.

II APPENDICES

APPENDIX I: QUESTIONNAIRES USED TO ASSESS CLINICAL OUTCOMES

OSWESTRY DISABILITY INDEX¹⁰⁶

This questionnaire is designed to give us information as to how your back (or leg) trouble affects your ability to manage in everyday life. Please answer every section. Mark one box only in each section that most closely describes you today.

Section 1 – Pain Intensity

- I have no pain at the moment.
- The pain is very mild at the moment.
- The pain is moderate at the moment
- The pain is fairly severe at the moment.
- The pain is very severe at the moment.
- The pain is the worst imaginable at the moment.

Section 2 – Personal Care (Washing, Dressing, etc.)

- I can look after myself normally without causing extra pain.
- I can look after myself normally but it is very painful.
- It is painful to look after myself and I am slow and careful.
- I need some help but manage most of my personal care.
- I need help every day in most aspects of self-care.
- I do not get dressed, wash with difficulty and stay in bed.

Section 3 – Lifting

- I can lift heavy weights without extra pain.
- I can lift heavy weights but it gives extra pain.
- Pain prevents me from lifting heavy weights off the floor, but I can manage if they are conveniently positioned, e.g., on a table.
- Pain prevents me from lifting heavy weights but I can manage light to medium weights if they are conveniently positioned.
- I can lift only very light weights.

Section 6 – Standing

- I can stand as long as I want without extra pain.
- I can stand as long as I want but it gives me extra pain.
- Pain prevents me from standing for more than one hour.
- Pain prevents me from standing for more than half an hour.
- Pain prevents me from standing for more than 10 minutes.
- Pain prevents me from standing at all.

Section 7 – Sleeping

- My sleep is never disturbed by pain.
- My sleep is occasionally disturbed by pain.
- Because of pain I have less than six hours sleep.
- Because of pain I have less than four hours sleep.
- Because of pain I have less than two hours sleep.
- Pain prevents me from sleeping at all.

Section 8 – Sex Life

- My sex life is normal and causes no extra pain.
- My sex life is normal but causes some extra pain.
- My sex life is nearly normal but is very painful.
- My sex life is severely restricted by pain.
- My sex life is nearly absent because of pain.
- Pain prevents any sex life at all.

o I cannot lift or carry anything at all.

Section 4 – Walking

- o Pain does not prevent me walking any distance.
- o Pain prevents me walking more than one mile.
- o Pain prevents me walking more than 1/4 mile.
- o Pain prevents me from walking more than 100 yards.
- o I can only walk using a stick or crutches.
- o I am in bed most of the time and have to crawl to the toilet.

Section 5 – Sitting

- o I can sit in any chair as long as I like.
- o I can sit in my favourite chair as long as I like.
- o Pain prevents me from sitting more than one hour.
- o Pain prevents me from sitting more than half an hour.
- o Pain prevents me from sitting more than 10 minutes.
- o Pain prevents me from sitting at all.

Section 9 – Social Life

- o My social life is normal and causes me no extra pain.
- o My social life is normal but increases the degree of pain.
- o Pain has no significant effect on my social life apart from limiting my more energetic interests, e.g., sports.
- o Pain has restricted my social life and I do not go out as often
- o Pain has restricted my social life to my home.
- o I have no social life because of pain.

Section 10 – Travelling

- o I can travel anywhere without pain.
- o I can travel anywhere but it gives extra pain.
- o Pain is bad but I manage journeys over two hours.
- o Pain restricts me to journeys of less than one hour.
- o Pain restricts me to short necessary journeys under 30 minutes.
- o Pain prevents me from travelling except to receive treatment.

Scoring System for ODI

Answers relate to the situation of 'today'. Each item has six response alternatives, ranging from 'no problem' to 'not possible'. The ODI score is calculated as follows: if the first statement ('no problem') is marked, the score is 0; if the last statement ('not possible') is marked, the score is 5. Intervening statements are scored accordingly to rank. So, for each item of six statements the maximum score is 5. If all 10 items are completed the score is calculated as follows: The ODI score (index) is calculated as: $(\text{Total score} / 5 * \text{number of questions answered}) * 100$ to obtain the score expressed in percentages. So the total ODI score ranges from 0 (no disability) to 100 (maximum disability).

Interpretation of Disability Scores

- 0%-20% Minimal disability
- 20%-40% Moderate disability
- 40%-60% Severe disability
- 60%-80% Crippled
- 80%-100% Patients are either bed-bound or exaggerating symptoms.

This can be evaluated by careful observation during the medical examination.

ZURICH CLAUDICATION QUESTIONNAIRE¹⁰⁷ OR SWISS SPINAL STENOSIS SCORE¹⁰⁶

In the past month, how would you describe:

1. The pain you have had on the average including pain in your back and buttocks as well as pain that goes down the legs?

None

Mild

Moderate

Severe

Very severe

2. How often have you had back, buttock, or leg pain?

Less than once a week

At least once a week

Every day, for at least a few minutes

Every day, for most of the day

Every minute of the day

3. The pain in your back or buttocks?

None

Mild

Moderate

Severe

Very severe

4. The pain in your legs or feet?

None

Mild

Moderate

Severe

Very severe

5. Numbness or tingling in your legs or feet?

None

Mild

Moderate

Severe

Very severe

6. Weakness in your legs or feet?

None

Mild

Moderate

Severe

Very severe

7. Problems with your balance?

No, I've had no problems with balance.

Yes, sometimes I feel my balance is off, or that I am not surefooted.

Yes, often I feel my balance is off, or that I am not surefooted.

In the past month, on a typical day

8. How far have you been able to walk?

More than 2 miles

More than 2 blocks, but less than 2 miles

More than 50 feet, but less than 2 blocks

Less than 50 feet

9. Have you taken walks outdoors or around the shops for pleasure?

Yes, comfortably

Yes, but sometimes with pain

Yes, but always with pain

No

10. Have you been shopping for groceries or other items?

Yes, comfortably

Yes, but sometimes with pain

Yes, but always with pain

No

11. Have you walked around the different rooms in your house or apartment?

Yes, comfortably

Yes, but sometimes with pain

Yes, but always with pain

No

12. Have you walked from your bedroom to the bathroom?

Yes, comfortably

Yes, but sometimes with pain

Yes, but always with pain

No

The scale relates to symptoms over the past month. The score is expressed as a percentage of the maximum possible score. Subsections of the scale include the symptom severity scale (Questions 1–7), subdivided into a pain domain (Questions 1–4) and a neuroischemic domain (Questions 5–7); the physical function scale (Questions 8–12). The symptom severity section has 7 questions that can receive a score from 1 to 5; the physical function section has 5 questions that can receive a score from 1 to 4; and the patient satisfaction section has 6 questions that can receive a score from 1 to 4. Scores of each section are averaged, and the lower the score; the better the outcome.

VISUAL ANALOGUE SCALE

A Visual Analogue Scale (VAS) is a measurement instrument that tries to measure a characteristic or attitude that is believed to range across a continuum of values and cannot easily be directly measured. For example, the amount of pain that a patient feels ranges across a continuum from none to an extreme amount of pain. This spectrum appears continuous \pm their pain does not take discrete jumps, as a categorization of none, mild, moderate and severe would suggest. It was to capture this idea of an underlying continuum that the VAS was devised.

Operationally a VAS is usually a horizontal line, 100 mm in length, anchored by word descriptors at each end. The patient marks on the line the point that they feel represents their perception of their current state. The VAS score is determined by measuring in millimetres from the left hand end of the line to the point that the patient marks.

How severe is your pain today?

No pain | _____ | Very severe
pain

SF-36 Health Survey

Instructions for completing the questionnaire: Please answer every question. Some questions may look like others, but each one is different. Please take the time to read and answer each question carefully by filling in the bubble that best represents your response.

1. In general, would you say your health is:

- Excellent
- Very good
- Good
- Fair
- Poor

2. Compared to one year ago, how would you rate your health in general now?

- Much better now than a year ago
- Somewhat better now than a year ago
- About the same as one year ago
- Somewhat worse now than one year ago
- Much worse now than one year ago

3. The following items are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much?

a. Vigorous activities, such as running, lifting heavy objects, participating in strenuous sports.

- Yes, limited a lot.
- Yes, limited a little.
- No, not limited at all.

b. Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf?

- Yes, limited a lot.
- Yes, limited a little.
- No, not limited at all.

c. Lifting or carrying groceries.

- Yes, limited a lot.
- Yes, limited a little.
- No, not limited at all.

d. Climbing several flights of stairs.

- Yes, limited a lot.
- Yes, limited a little.
- No, not limited at all.

e. Climbing one flight of stairs.

- Yes, limited a lot.
- Yes, limited a little.
- No, not limited at all.

f. Bending, kneeling or stooping.

- Yes, limited a lot.

- Yes, limited a little.
 - No, not limited at all.
- g. Walking more than one mile.
- Yes, limited a lot.
 - Yes, limited a little.
 - No, not limited at all.
- h. Walking several blocks.
- Yes, limited a lot.
 - Yes, limited a little.
 - No, not limited at all.
- i. Walking one block.
- Yes, limited a lot.
 - Yes, limited a little.
 - No, not limited at all.
- j. Bathing or dressing yourself.
- Yes, limited a lot.
 - Yes, limited a little.
 - No, not limited at all.
4. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of your physical health?
- a. Cut down the amount of time you spent on work or other activities?
- Yes No
- b. Accomplished less than you would like?
- Yes No
- c. Were limited in the kind of work or other activities
- Yes No
- d. Had difficulty performing the work or other activities (for example, it took extra time)
- Yes No
5. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?
- a. Cut down the amount of time you spent on work or other activities?
- Yes No
- b. Accomplished less than you would like
- Yes No
- c. Didn't do work or other activities as carefully as usual
- Yes No
6. During the past 4 weeks, to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbors, or groups?
- Not at all
 - Slightly
 - Moderately

- Quite a bit
- Extremely

7. How much bodily pain have you had during the past 4 weeks?

- Not at all
- Slightly
- Moderately
- Quite a bit
- Extremely

8. During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?

- Not at all
- Slightly
- Moderately
- Quite a bit
- Extremely

9. These questions are about how you feel and how things have been with you during the past 4 weeks. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the past 4 weeks.

a. did you feel full of pep?

- All of the time
- Most of the time
- A good bit of the time
- Some of the time
- A little of the time
- None of the time

b. have you been a very nervous person?

- All of the time
- Most of the time
- A good bit of the time
- Some of the time
- A little of the time
- None of the time

c. have you felt so down in the dumps nothing could cheer you up?

- All of the time
- Most of the time
- A good bit of the time
- Some of the time
- A little of the time
- None of the time

d. have you felt calm and peaceful?

- All of the time

- Most of the time
- A good bit of the time
- Some of the time
- A little of the time
- None of the time

e. did you have a lot of energy?

- All of the time
- Most of the time
- A good bit of the time
- Some of the time
- A little of the time
- None of the time

f. have you felt downhearted and blue?

- All of the time
- Most of the time
- A good bit of the time
- Some of the time
- A little of the time
- None of the time

g. did you feel worn out?

- All of the time
- Most of the time
- A good bit of the time
- Some of the time
- A little of the time
- None of the time

h. have you been a happy person?

- All of the time
- Most of the time
- A good bit of the time
- Some of the time
- A little of the time
- None of the time

i. did you feel tired?

- All of the time
- Most of the time
- A good bit of the time
- Some of the time
- A little of the time
- None of the time

10. During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting friends, relatives, etc.)?

- All of the time
- Most of the time
- Some of the time
- A little of the time
- None of the time

11. How TRUE or FALSE is each of the following statements for you?

a. I seem to get sick a little easier than other people

- Definitely true
- Mostly true
- Don't know
- Mostly false
- Definitely false

b. I am as healthy as anybody I know

- Definitely true
- Mostly true
- Don't know
- Mostly false
- Definitely false

c. I expect my health to get worse

- Definitely true
- Mostly true
- Don't know
- Mostly false
- Definitely false

d. My health is excellent

- Definitely true
- Mostly true
- Don't know
- Mostly false
- Definitely false

The SF-36 measures eight concepts: physical functioning (PF), role limitations due to physical health (RP), bodily pain (BP), general health perceptions (GH), vitality (VT), social functioning (SF), role limitations due to emotional problems (RE), and general mental health (MH). Two summary measures of physical (PCS) and mental (MCS) health are constructed from the eight scales.

Content-based interpretation

Content-based interpretation uses information about item content and patterns of response choices to assign meaning to scores. For example, someone at the top score of the SF-36 Physical Functioning (PF) scale does not have limitations in any of the SF-36 activities due to health. A person scoring at the bottom of the PF scale is very limited in all activities, including bathing and dressing. Scale scores in between these extremes can be interpreted in relation to responses to a single item from the scale, as can the two SF-36 summary measures.

Construct-based interpretation

Constructs are abstract properties, such as physical or mental health, which are measured with the SF-36. The SF-36 Physical Functioning, Role Physical, and Bodily Pain scales have high correlations with each other in general populations, as do the Mental Health, Role Emotional, and Social Functioning scales. This pattern of relationships is indicative of a relationship between the scales and the underlying constructs of physical and mental health.

Criterion-based interpretation

Criterion-based interpretation uses information on the relationship of scores to external variables to determine their meaning. Scores can be interpreted in relation to clinically and socially meaningful variables, such as job loss, utilization of health care services, likelihood of a clinical diagnosis, or death.

APPENDIX 2: SEARCH STRATEGY FOR PRIMARY STUDIES

Medline Ovid

Date	June 23rd 2009
Database (name + access ; eg Medline OVID)	Medline Ovid
Date covered (segment)	1980 - Current
Search Strategy (attention, for PubMed, check « Details »)	See below
Note	137 references – 8 duplicates = 129 original references

1. meta-analysis.pt,ti,ab,sh.
2. 1 or (meta anal\$ or metaanal\$).ti,ab,sh.
3. (methodol\$ or systematic\$ or quantitativ\$).ti,ab,sh.
4. ((methodol\$ or systematic\$ or quantitativ\$) adj (review\$ or overview\$ or survey\$)).ti,ab,sh.
5. (medline or embase or index medicus).ti,ab.
6. ((pool\$ or combined or combining) adj (data or trials or studies or results)).ti,ab.
7. 6 or 4 or 3 or 5
8. 7 and review.pt,sh.
9. 8 or 2
10. Randomized controlled trials/
11. Randomized controlled trial.pt.
12. Random allocation/
13. Double blind method/
14. Single blind method/
15. Clinical trial.pt.
16. exp clinical trial/
17. or/10-16
18. (clinic\$ adj trial\$1).tw.
19. ((singl\$ or doubl\$ or treb\$ or tripl\$) adj (blind\$3 or mask\$3)).tw.
20. Placebos/
21. Placebo\$.tw.
22. Randomly allocated.tw.
23. (allocated adj2 random).tw.
24. or/18-23
25. 17 or 24
26. Case report.tw.
27. Letter.pt.
28. Historical article.pt.
29. Review of reported cases.pt.
30. Review, multicase.pt.
31. or/26-30
32. 25 not 31
33. 9 or 32
34. Comparative Study/
35. exp Evaluation Studies/
36. Follow-up Studies/
37. Prospective Studies/
38. (control\$ or prospectiv\$ or volunteer\$).tw.
39. Cross-Over Studies/
40. or/34-39
41. 33 or 40
42. Sciatica/
43. Low Back Pain/

44. Spinal Stenosis/ or Intermittent Claudication/ or Nerve Compression Syndromes/
45. Osteoarthritis, Spine/
46. Spondylosis/
47. Spondylolisthesis/
48. or/42-47
49. Lumbar Vertebrae/
50. 49 and 48
51. ((spine\$ or spinal) adj4 decompres\$).mp.
52. (stabilis\$ adj4 (spine\$ or spinal)).mp.
53. (pedicle adj4 screw).mp.
54. ((spine\$ or spinal) adj4 spacer).mp.
55. interspinous process decompression.mp.
56. X Stop.mp.
57. Coflex.mp.
58. Wallis.mp.
59. DIAM.mp.
60. Dynesis.mp.
61. interspinous distraction.mp.
62. dynamic neutralization.mp.
63. or/51-62
64. 63 and 50 and 41
65. limit 64 to humans
66. outcome.mp. or Treatment Outcome/
67. 65 and 66

Embase

Date	April 8th 2009
Database (name + access ; eg Medline OVID)	Embase
Date covered (segment)	1980 - Current
Search Strategy (attention, for PubMed, check « Details »)	See below
Note	51 references – 6 duplicates = 45 original references

- #1 **'meta analysis'/exp OR 'systematic review'/exp OR 'clinical trial'/exp OR 'observational studies'/exp OR 'follow up'/exp AND [1950-2009]/py** **1,072,270**
- #2 **('lumbar vertebrae'/exp OR 'lumbar spine'/exp OR 'spinal disease'/exp OR (spine* AND ('stenosis'/de OR instability)) OR lss OR (herniat* AND (disc* OR disk*)) OR 'spondylolisthesis'/de OR 'spondylarthrosis'/de OR (degenerative AND disc AND 'disease'/de) OR (degenerative AND disk AND 'disease'/de) OR (facet AND 'joint'/de AND 'arthritis'/de) OR (facet AND 'arthropathy'/de) OR 'lumbar disc hernia'/dm_su OR 'spine instability'/dm_su OR 'intervertebral disk degeneration'/dm_su OR 'intervertebral disc hernia'/dm_su OR 'spine surgery'/exp OR 'lumbar spine'/exp OR 'lumbar disk'/exp OR 'spine stabilization'/exp OR 'spine'/exp OR spin*) AND ((interspinous AND (implant* OR device* OR distract*)) OR ((dynamic OR elastic) AND (neutrali?ation OR stabili?ation)) OR 'non fusion' OR 'dynesys' OR 'x stop' OR (wallis AND system) OR coflex OR (intervertebral AND assisted AND 'motion'/de) OR diam) AND [humans]/lim AND [1950-2009]/py AND [1950-2009]/py** **519**

#3	'cervical spine'/exp OR cervical AND [1950-2009]/py	144,151
#4	#2 NOT #3	390
#5	'treatment outcome'/exp AND [1950-2009]/py	602,621
#6	#1 AND #4 AND #5	51

APPENDIX 3: LIST OF EXCLUDED STUDIES AFTER IN-DEPTH SCREENING BY REASON OF REJECTION

INAPPROPRIATE DESIGN

Bartels RHMA. The X STOP device [1]. *Journal of Neurosurgery: Spine*. 2007;6:620-N 6.

Grob D, Benini A, Junge A, Mannion AF. Clinical experience with the dynesys semirigid fixation system for the lumbar spine: Surgical and patient-oriented outcome in 50 cases after an average of 2 years. *Spine*. 2005;30(3):324-31.

Eichholz KM, Fessler RG. Is the X STOP interspinous implant a safe and effective treatment for neurogenic intermittent claudication? *Nature clinical practice. Neurology*. 2006;2(1):22-3.

Heijnen S.A.F and Kramer F.J.K (2004). Spinale distractie als therapie bij lumbale wervelkanaalstenose - de eerste resultaten. *Ned. Tijdschrift voor Orthopaedie* 11(4):199-203.

Kim DH, Anderson PA. Interspinous Process Distraction Devices for Spinal Stenosis. *Seminars in Spine Surgery*. 2007;19(3):206-14.

Onda A, Otani K, Konno S, Kikuchi S. Mid-term and long-term follow-up data after placement of the Graf stabilization system for lumbar degenerative disorders. *Journal of Neurosurgery Spine*. 2006;5(1):26-32.

Sapkas GS, Themistocleous GS, Mavrogenis AF, et al.. Stabilization of the Lumbar Spine Using the Dynamic Neutralization System. *ORTHOPEDICS* 2007; 30:859

Scarfo GB, Muzii VF. Re-equilibration not arthrodesis. Contribution to the functional treatment of lumbar vertebral instability. *Rivista di Neuroradiologia*. 2003;16(4):657-74.

Sénégas J, Vital JM, Pointillart V, Mangione P. Clinical evaluation of a lumbar interspinous dynamic stabilization device (the Wallis system) with a 13-year mean follow-up. *Neurosurg Rev*. 2009

Sengupta DK. Point of view: Dynamic stabilization in addition to decompression for lumbar spinal stenosis with degenerative spondylolisthesis. *Spine*. 2006;31:450%N 4.

Taylor J, Pupin P, Delajoux S. Device for intervertebral assisted motion: technique and initial results. *Neurosurg Focus* 22 (1):E6, 2007

Verhoof OJ, Bron JL, Wapstra FH, Van Royen BJ. High failure rate of the interspinous distraction device (X-Stop) for the treatment of lumbar spinal stenosis caused by degenerative spondylolisthesis. *European Spine Journal*. 2008;17(2):188-92.

Weiner BK. Interspinous process decompression system (X STOP) device affords superior outcomes and equal safety to nonoperative therapy. *Spine*. 2005;30(24):2846-7.

INAPPROPRIATE INTERVENTION

Kim YS, Zhang HY, Moon BJ, Park KW, Ji KY, Lee WC, et al. Nitinol spring rod dynamic stabilization system and Nitinol memory loops in surgical treatment for lumbar disc disorders: short-term follow up. *Neurosurgical focus*. 2007;22(1):E10.

Korovessis P, Papazisis Z, Koureas G, Lambiris E. Rigid, semirigid versus dynamic instrumentation for degenerative lumbar spinal stenosis: a correlative radiological and clinical analysis of short-term results. *Spine*. 2004;29(7):735-42.

Korovessis P, Repantis T, Zacharatos S, Zafiropoulos A. Does Wallis implant reduce adjacent segment degeneration above lumbosacral instrumented fusion? *Eur Spine J*. 2009

Markwalder TM, Wenger M. Dynamic stabilization of lumbar motion segments by use of Graf's ligaments: Results with an average follow-up of 7.4 years in 39 highly selected, consecutive patients. *Acta Neurochirurgica*. 2003;145(3):209-14.

Saxler G, Wedemeyer C, Von Knoch M, Render UM, Quint U. Follow-up study after dynamic and static stabilisation of the lumbar spine. *Zeitschrift fur Orthopadie und Ihre Grenzgebiete*. 2005;143(1):92-9.

INAPPROPRIATE OUTCOMES

Caserta S, La Maida GA, Misaggi B, Peroni D, Pietrabissa R, Raimondi MT, et al: Elastic stabilization alone or combined with rigid fusion in spinal surgery: a biomechanical study and clinical experience based on 82 cases. *Eur Spine J* 11 (2 Suppl): S192-S197, 2002

ONLY ON ABSTRACT FORM

Zucherman J, Hsu K, Hartjen C, Mehalic T, Implicito D, Martin M, et al. Treatment of lumbar spinal stenosis with an interspinous spacer 1880 *Euro Spine J*. 2002;11(S01):S13.

APPENDIX 4: QUALITY ASSESSMENT

HTA REPORTS

INAHTA checklist	MSAC 2007	ASERNIP-S 2006	CTAF 2006	IECS 2006
Appropriate contact details for further information?	Yes	Yes	No	Yes
Authors identified?	Yes	No	No	Yes
Statement regarding conflict of interest?	No	No	No	Yes
Statement on whether report externally reviewed?	Yes	No	No	No
Short summary in non-technical language?	Yes	No	Partly	Yes
Reference to the policy question that is addressed?	Yes	No	Yes	No
Reference to the research question that is addressed?	Yes	No	Yes	Partly
Scope of the assessment specified?	Yes	Yes	Yes	Partly
Description of the assessed health technology?	Yes	Yes	Yes	Yes
Details on source of information and literature search strategies provided?	Yes	Partly	Partly (3/10)	Partly (2/10)
Information on basis for the assessment and interpretation of selected data information?	Yes	No	No	No
Information on context?	Yes	Yes	No	Yes
Findings of the assessment discussed?	Yes	Partly	Yes	No
Conclusions from assessment clearly stated?	Yes	No	Yes	Yes
Suggestions for further action?	Yes	Partly	Partly	No
Overall appraisal	Good	Poor	Poor	Poor

RANDOMISED CONTROLLED TRIALS

Cochrane checklist	Anderson 2006	Hsu 2006
Randomization?	Yes	Yes
Blinding of randomization?	Not stated	Yes
Blinding of patients?	No	No
Blinding of care provider?	No	No
Blinding of outcome assessor?	Not stated	Not stated
Similar groups at baseline?	Yes	Yes
Follow-up long enough?	Yes	Yes
Intention-to-treat analysis?	Yes	Yes
Comparable treatment of groups?	Yes	Yes
Overall appraisal	Average	Average

CASE-CONTROL STUDIES

CRD checklist	Kim 2007	Kong 2007
Is the case definition explicit?	Yes	Yes
Has the disease state of the cases been reliably assessed and validated?	Yes	Yes
Were the controls randomly selected from the source of population of the cases?	No	No
How comparable are the cases and controls with respect to potential confounding factors?	Not reported	Not reported
Were interventions and other exposures assessed in the same way for cases and controls?	No	No
How was the response rate defined?	Not defined	Not defined
Were the non-response rates and reasons for non-response the same in both groups?	No	Not reported
Is it possible that over-matching has occurred in that cases and controls were matched on factors related to exposure?	Yes	Yes
Was an appropriate statistical analysis used (matched or unmatched)?	No	No
Overall appraisal	Poor	Poor

BEFORE-AND-AFTER STUDIES

CRD checklist	Kuchta 2009	Brussee 2008	Siddiqui 2007	Floman 2007	Lee 2008
Is the study based on a representative sample selected from a relevant population?	Yes	Yes	Yes	Yes	Yes
Are the criteria for inclusion explicit?	Yes	Yes	Yes	Yes	Yes
Did all individuals enter the survey at a similar point in their disease progression?	Yes	Yes	Yes	Yes	No
Was follow-up long enough for important events to occur?	Yes	Yes	Yes	Yes	Yes
Were outcomes assessed using objective criteria or was blinding used?	Yes	Yes	Yes	Yes	Yes
If comparisons of sub-series are being made, was there sufficient description of the series and the distribution of prognostic factors?	NA	NA	NA	NA	NA
Overall appraisal	Good	Good	Good	Good	Good

CRD checklist	Mariottini 2005	Welch 2007	Kondrashov 2006	Schaeren 2008	Würgler Hauri 2008
Is the study based on a representative sample selected from a relevant population?	Yes	Yes	No	Yes	Yes
Are the criteria for inclusion explicit?	No	Yes	No	Yes	Yes
Did all individuals enter the survey at a similar point in their disease progression?	No	Yes	Not reported	Yes	Yes
Was follow-up long enough for important events to occur?	Yes	Yes	Yes	Yes	Yes
Were outcomes assessed using objective criteria or was blinding used?	No	Yes	No	Yes	Yes
If comparisons of sub-series are being made, was there sufficient description of the series and the distribution of prognostic factors?	NA	NA	NA	NA	NA
Overall appraisal	Poor	Good	Poor	Good	Good

APPENDIX 5: EVIDENCE TABLES

Interspinous devices: X STOP

Study ID	Ref	Population	Intervention	Key efficacy findings	Key safety findings	Comments
Interspinous decompression device: X STOP						
HTA Reports						
MSAC 2007 Australia		People with symptomatic lumbar spinal stenosis, degenerative spondylolisthesis, herniated disc or facet joint osteoarthritis who have failed to respond to conservative management	X STOP surgery 1–2 levels treated	<p>Outcomes assessment: Zurich claudication questionnaire (ZCQ) and the SF–36 (bodily pain, quality of life and functioning subscales)</p> <p>Reducing pain Mean pain assessed with SF-36 was significantly lower 1 year post insertion of the X STOP device (56.1) than prior to surgery (24.5) ($p<0.05$) (Zucherman et al. 2005)</p> <p>Two studies used the ZCQ (Pain 1-5) and found reductions of symptom severity in patients who had received the X STOP device: -from 2.74 to 2.26 at 9-18 months; significant improvement in 40% (Lee et al. 2004; $n=10$) - change of 45.5% at 2 years ($p<0.05$); significant improvement in 60.2% (Zucherman et al. 2004; $n=100$)</p> <p>Improving quality of life SF–36, where 0 = worst possible outcome, 100 = best possible outcome.</p>	<p>Major complications^a: occurred in up to 3% of patients: One death was caused by pulmonary oedema in a patient with a history of cardiovascular disease; one dislodgement/ migration requiring removal of implant; one malpositioned implants (Zucherman et al. 2005).</p> <p>Minor complications: respiratory distress, wound swelling and pain occurred in up to 8% of patients (Zucherman et al. 2005). No intra-operative complications or site-related postoperative complications such as implant failure, bony failure or infection (Lee et al. 2004).</p> <p>Radiographic findings At 6-month follow-up, 2% of patients had radiologically detected complications or technical errors without requiring further treatment (Zucherman et al 2005).</p>	<p>Literature searches were conducted up until April 2006 from AustHealth, Cinahl, Cochrane Library, Current Contents, Embase, Pre-medline, Proceedings First, Web of Science and EconLit.</p> <p>HTA report</p> <p>2 studies were included: - 1 uncontrolled before-and-after case series (Lee et al. 2004; $n=10$); - 1 RCT (Zucherman et al. 2005; $n=100$); this RCT did not report information on the patients treated with the comparator ; so this study is treated as a case series</p>

			<p>Zucherman et al. (2004) obtained statistical significant changes ($p < 0.05$) after 1 year on all subscales:</p> <ul style="list-style-type: none"> - General health: 70.2 to 73.0 - Mental health: 64.6 to 66.8 - Role emotional: 52.0 to 77.1 - Vitality: 47.4 to 53.0 <p>The clinical importance of these differences is unclear.</p> <p>Functional status Zucherman et al. (2004) found great benefits for the functioning subscales of the SF-36 (0 to 100), all of which were statistically significant at 1 year follow-up ($p < 0.05$)</p> <ul style="list-style-type: none"> - Physical function: 31.7 to 62.2 - Social function: 58.5 to 79.3 - Role physical: 13.5 to 57.0 <p>In Lee et al. (2004) and Zucherman et al. (2005), functioning was significantly improved in 10–57% of patients (ZCQ).</p> <p>Reoperation Zucherman et al (2005) reported that six patients (6.5% of those followed up) who received the X STOP device underwent laminectomy due to unresolved stenosis symptoms during a 2 year follow-up period.</p> <p>Conclusion: Based on the limited evidence available for these</p>	<p>Conclusion: Based on the limited evidence available for these devices, the MSAC finds that interspinous spacer devices are as safe as the conventional operations (if the devices were placed without laminectomy, the risks and surgical exposure would be less than for conventional laminectomy)</p>
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				devices, the MSAC finds that interspinous spacer devices may be as effective in selected cases as laminectomy and fusion and may be associated with a better outcome in patients with limited or localised (single level) disc disease		
Systematic review						
Gibson and Waddell 2005 Cochrane Collaboration (UK)		Elderly patients with one or two level central stenosis	X STOP surgery 1–2 levels treated	Outcome: Moderate/severe pain Number of patients : 167 Statistical method : Odds Ratio (M-H, Random, 95% CI) Effect size : 0.14 [0.07, 0.29]	Outcome : Secondary surgery Number of patients : 196 Statistical method : Odds Ratio (M-H, Random, 95% CI) Effect size : 0.26 [0.09, 0.73]	Systematic review on surgery for degenerative lumbar spondylosis Literature searches were conducted up until 31 March 2005 from CENTRAL, MEDLINE, PubMed, Spine and ISSLS abstracts, with citation tracking from the retrieved articles. Only one RCT : Zucherman's trial (2005)
Primary studies						
Kuchta 2009 Germany		175 patients with lumbar stenosis and neurologic claudication (mean age 69.4 years; range 41-91 years)	X-Stop L4-L5 (64%) L3-L4 (27%) L2-L3 (7.4%) L1-L2 (1.1%) L5-S1 (3.4%)	Outcomes assessment: VAS (leg pain) and Oswestry Disability Index (ODI) Reducing Pain (VAS) From mean 61.2±29.8 (range 20-100) to mean 39±28.3 (range 0-75); p<0.001 Oswestry Disability Index (mean scores) From mean 32.6±16.0 (range 8-80) to mean 20.3±17.5 (range 0-42); p<0.001	In 8/175 patients (4.6%), X-Stop was removed due to unsatisfactory results and a microsurgical decompression was performed. No complications were reported.	Prospective clinical study Last Follow-up at 2 years

<p>Brussee 2008 The Netherlands</p>	<p>65 patients (n=62) with a classical neurogenic claudication due to lumbar spinal stenosis</p> <p>mean age was 64.4 ± 10.0 y (37.0–85.0 y)</p>	<p>20 patients received two X-Stops and 42 patients received one X-Stop.</p> <p>Five times, X-stop was implanted at level L2–L3, in 29 at L3–L4, and 51 at L4–L5.</p> <p>Implanted sizes were: three times a 10 mm, six times a 12 mm, 56 times a 14 mm, and 20 times a 16 mm device.</p>	<p>Reoperation rate: 9.2% had a reoperation because of persistent or recurrent symptoms</p> <p>Walking distance (self-assessed) : Pre-operatively, 34% of patients were able to walk more than 250 m (no patient was able to walk more than 3 km). Postoperatively, 62% of patients were able to walk more than 250 m (including 16% of patients able to walk more than 3 km) ($X^2=9.34$; df 1; $p=0.0022$).</p> <p>Zürich Claudication Questionnaire (ZCQ) : A good result was achieved when the satisfaction score was at least moderately satisfied (mean score 2.0 or less), the severity score was at least improved 0.5 as was the vitality score.</p> <p>→ 30.6% of the patients were 'very satisfied' → 74.2% patients reported to be very or moderately satisfied.</p> <p>Overall satisfaction was not influenced by the amount of X-Stops ($p = 0.771$).</p>	<p>Complications: No intra or post-operative complications</p>	<p>Before-and-after study</p> <p>Mean follow up: 1.0 ± 0.75 years</p> <p>Univariate analysis</p>
<p>Siddiqui 2007 UK</p>	<p>24 patients (median age was 71.5 years) with MRI confirmed diagnosis of stenosis at 1 or 2 levels.</p>	<p>X Stop</p> <p>34 levels were operated of which 14 were</p>	<p>Outcomes assessment: Oswestry Disability Index (ODI) and Zurich Claudication Questionnaire (ZCQ): symptom severity (1 to 5); physical function</p>	<p>Adverse events Two of the early patients (5%) in the study had spinous process fracture at the time of the operation and subsequently</p>	<p>Prospective observational study</p> <p>40 consecutive patients were recruited; 16 patients failed</p>

		<p>single levels and 10 double levels (L2-3- 2; L3-4- 9; L4-5- 22; L5S1- 1).</p>	<p>(1 to 4); patient satisfaction (1 to 4).</p> <p>Zurich Claudication Questionnaire (mean scores)</p> <p>- symptom severity</p> <table border="1"> <tr> <td>pre-op</td> <td>3mo</td> <td>6mo</td> <td>12mo</td> </tr> <tr> <td>3.37</td> <td>2.42</td> <td>2.65</td> <td>2.83</td> </tr> </table> <p>- physical function</p> <table border="1"> <tr> <td>pre-op</td> <td>3mo</td> <td>6mo</td> <td>12mo</td> </tr> <tr> <td>2.45</td> <td>2.05</td> <td>2.16</td> <td>2.19</td> </tr> </table> <p>- patient satisfaction</p> <table border="1"> <tr> <td>pre-op</td> <td>3mo</td> <td>6mo</td> <td>12mo</td> </tr> <tr> <td></td> <td>1.90</td> <td>1.91</td> <td>2.12</td> </tr> </table> <p>% patients with clinical improvement</p> <p>- symptom severity</p> <table border="1"> <tr> <td>3mo</td> <td>6mo</td> <td>12mo</td> </tr> <tr> <td>71%</td> <td>54%</td> <td>54%</td> </tr> </table> <p>- physical function</p> <table border="1"> <tr> <td>3mo</td> <td>6mo</td> <td>12mo</td> </tr> <tr> <td>45%</td> <td>42%</td> <td>43%</td> </tr> </table> <p>- patient satisfaction</p> <table border="1"> <tr> <td>3mo</td> <td>6mo</td> <td>12mo</td> </tr> <tr> <td>79%</td> <td>79%</td> <td>71%</td> </tr> </table> <p>Oswestry Disability Index (mean scores)</p> <table border="1"> <tr> <td>pre-op</td> <td>3mo</td> <td>6mo</td> <td>12mo</td> </tr> <tr> <td>48</td> <td>35</td> <td>36</td> <td>37</td> </tr> </table> <p>Maximal clinical improvement, whether significant or not, occurs</p>	pre-op	3mo	6mo	12mo	3.37	2.42	2.65	2.83	pre-op	3mo	6mo	12mo	2.45	2.05	2.16	2.19	pre-op	3mo	6mo	12mo		1.90	1.91	2.12	3mo	6mo	12mo	71%	54%	54%	3mo	6mo	12mo	45%	42%	43%	3mo	6mo	12mo	79%	79%	71%	pre-op	3mo	6mo	12mo	48	35	36	37	<p>underwent formal surgical decompression (they were excluded from this follow-study)</p> <p>Two patients had a dorsally slipped implant at 1 year with symptoms of neurogenic claudication and underwent removal of the implant with decompression and fusion.</p>	<p>to complete all the questionnaires at all time intervals, 2 were excluded because removal of X- Stop before this follow-up assessment, 1 patient was declared unfit for surgery</p>
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				by 3 months and then gradually declines; 7/24 (29% of patients) by 12 months underwent caudal epidural injection for the recurrence of their symptoms of leg pain and neurogenic claudication.		
Anderson 2006 USA		<p>75 patients with degenerative spondylolisthesis</p> <p>Patients were at least 50 years of age, had to have their symptoms relieved by sitting or flexion, and had to have completed at least a 6-month course of non-operative trt. One or two-level degenerative spondylolisthesis was present.</p>	<p>Intervention group (n=42): X Stop</p> <p>Control group (n=33): at least one epidural steroid injection and additional injections at the discretion of the investigator.</p> <p>Patients also received non steroidal anti-inflammatory drugs, analgesic agents, and physical therapy as needed.</p>	<p>ZCQ (symptom severity, function, and patient satisfaction)</p> <p>In the X STOP device group, the baseline ZCQ score was significantly improved at all postoperative periods. The baseline ZCQ score was 50.4 and at 2-year follow up it was 23.1. The immediate improvement was sustained for at least 24 months.</p> <p>There was no significant improvement in the control group for ZCQ score at any follow-up interval.</p> <p>Patient satisfaction</p> <p>At 2 years, the mean patient satisfaction score was 1.55 in the X STOP system and 2.8 in the control group. This difference was statistically significant.</p> <p>Overall health status (SF-36)</p> <p>Mental score was not significantly different than that in the normal asymptomatic population, and did not change at 2 years in both groups.</p>	<p>Adverse events There was one procedure-related adverse event in the X STOP device group, an incisional complication that resolved after 1 week of oral antibiotic therapy.</p> <p>There was one device-related adverse event, a malpositioned implant that was later detected on radiographic examination.</p>	<p>Authors presented this study as a RCT with block randomization at each investigational site with sample size calculation (described in a letter to editor).</p> <p>However, this study is a cohort analysis of a RCT. The cohort studied consisted of patients who had grade I spondylolisthesis as well as spinal stenosis</p> <p>Clinical findings were recorded at 6 weeks and at 6, 12, and 24 months postoperatively</p>

				<p>Physical score indicated poor function in both groups: IG (31.53 ± 1.68) vs. CG (28.19 ± 1.29). Significant improvement was seen in the X STOP group (41.19 ± 1.97), whereas no change in baseline score was observed in the control group (28.14 ± 1.10)</p> <p>Overall clinical success Overall 2-year clinical success, defined as a case in which all three criteria (15-point ZCQ improvement, a patient satisfaction score < 2.5, and no further surgery) were met, was demonstrated in 63.4% of X STOP patients and in 12.9% in control patients.</p> <p>Additional Surgery Five patients in the IG and 4 patients in the CG required laminectomy or laminectomy and fusion. The difference between surgical rates in the two groups was not statistically different</p>		
Hsu 2006 USA	<p>191 patients with degenerative spondylolisthesis</p> <p>Patients were at least 50 years of age, had symptoms of radiographically confirmed one-or two-</p>	<p>Intervention group (n=100): X Stop</p> <p>Control group (n=91): at least one epidural steroid injection and additional</p>	<p>Outcomes were assessed for 82 patients in the X Stop group and 53 patients in the non operative group.</p> <p>At 2 years, 1) mean domain scores in X STOP-treated patients were significantly greater than those in patients treated non operatively,</p>		<p>RCT with block randomization at each investigational site with sample size calculation</p> <p>An intent-to-treat analysis was performed at the 2-year time point for the X STOP and non operative groups</p>	

		level LSS, and had leg, buttock, or groin pain, with or without back pain, that could be relieved during flexion.	injections at the discretion of the investigator. Patients also received non steroidal anti-inflammatory drugs, analgesic agents and physical therapy as needed.	with the exception of the mean General Health (GH), Role Emotional, and Mental Component scores; and 2) mean post treatment domain scores documented in X STOP-treated patients were significantly greater than mean pre treatment scores, with the exception of mean GH scores.		and compared with the 2-year results reported in other studies. Clinical findings were recorded at 6 weeks and at 6, 12, and 24 months postoperatively
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^a Adverse events were classified as serious if they were likely to require hospitalisation or further surgery

Interspinous devices: Wallis

Study ID	Ref	Population	Intervention	Key efficacy findings	Key safety findings	Comments
Interspinous decompression device: Wallis						
HTA Reports						
MSAC 2007		80 patients with recurrent herniated disc(s).	<p>Intervention group: Wallis inserted after a discectomy</p> <p>Control group: discectomy alone</p>	<p>Outcomes assessment: Visual analogue scale (VAS), Oswestry disability index (ODI)</p> <p>Reducing pain Wallis device resulted in a greater reduction in patient pain (74%, n=40) than discectomy alone (52%, n=40), although it is unclear whether the difference was statistically or clinically significant (Senegas 2002).</p> <p>Analgesic use In Senegas (2002), the rate of analgesic use prior to surgery is unknown; however, only 20% of patients who received the Wallis device were taking analgesics after surgery compared to 42.5% in the discectomy alone group</p> <p>Functional improvement Patients receiving the Wallis had</p>	<p>No major complications were reported.</p> <p>Minor complications: no significant difference in minor safety outcomes between the two treatment groups (RR 1.17; 95% CI: 0.43 - 3.17)</p>	<p>Literature searches were conducted up until April 2006 from AustHealth, Cinahl, Cochrane Library, Current Contents, Embase, Pre-medline, ProceedingsFirst, Web of Science and EconLit.</p> <p>I prospective cohort study (Senegas 2002)</p>

			<p>more functional improvement (ODI, 58.2±22 to 16.4± 10) than those only receiving discectomy (ODI, 54.7±16 to 22±11) (average 3 years 4 months, minimum of 1 year).</p> <p>Subsequent operations</p> <p>Senegas (2002) reported no difference in rate of reoperations between the patients who received discectomy and the Wallis device versus a discectomy alone (7.5%; RR=1; 95% CI 0.22, 4.66).</p>		
Primary studies					
Floman 2007	37 consecutive patients, 26 men and 11 women with an age range of 15 to 58 years (average 36), with a voluminous disc herniation and preservation of at least 50% of disc space height	Surgery with disc excision and Wallis implant (level L4-5)	<p>Re-herniation</p> <p>13% of patients were diagnosed by contrast enhanced MRI as suffering from recurrent herniation (5/37), occurring at level L4-5 between 1 and 9 months after the index surgery. Two of the 5 patients underwent additional discectomy and fusion.</p> <p>Reducing pain (14 patients)</p> <p>The average preoperative VAS for back pain dropped from 6.6 to 1.4 and the average VAS for leg pain dropped from 8.2 to 1.5 (p<0.05).</p>		<p>Case series study conducted prospectively in 37 patients.</p> <p>Most outcomes were only assessed in a subsample of 14 patients.</p> <p>The nonparametric Wilcoxon test was used to analyze the difference in the preoperative and postoperative ODI, SF-36 and VAS scores for leg and back pain</p>

				<p>Disability (14 patients)</p> <p>The average preoperative ODI dropped from 43 to 12.7 ($p < 0.05$).</p> <p>Overall health (14 patients)</p> <p>The general SF-36 score improved by a mean of 26.9 points ($p < 0.05$).</p>		
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Pedicle screws: Dynesys

Study ID	Ref	Population	Intervention	Key efficacy findings	Key safety findings	Comments
Pedicle screw: Dynesys						
HTA Reports						
MSAC 2007		Patients diagnosed with disc degeneration, spinal stenosis and instability	<p>Intervention group: Dynesys with decompression</p> <p>Comparators: decompression alone, or decompression and fusion surgery</p>	<p>Outcomes assessment: visual analogue scale (VAS), Zurich claudication questionnaire (ZCQ) and the SF-36 (bodily pain and functioning subscales), Oswestry disability index (ODI)</p> <p>Reducing pain</p> <p>Putzier 2005: At 3 months, Dynesys was as effective at reducing pain (VAS) as decompression surgery alone (74.3% of patients with complete remission vs. 71.4%).</p> <p>Cakir 2003: patients with fusion reported less pain (SF-36) after 14 months than patients with Dynesys (statistical significance not calculated).</p> <p>Analgesic use</p> <p>1 uncontrolled case series (Schnake et al. 2006) found that significantly fewer analgesics were</p>	<p>Major adverse events^a (malpositioning of screws and pedicle fractures) were reported in 6 uncontrolled before-and-after case series (361 patients): serious adverse event rates between 2.9 and 25.8% of patients (median of 5%)</p> <p>No controlled studies identified serious adverse events relating to lumbar non-fusion posterior stabilization devices.</p> <p>Minor adverse events (dural lesions and superficial wound infections)</p> <p>1) in 2 comparative studies (104 patients): similar rates of minor complications between Dynesys and the comparative treatments:</p> <p>- decompression without fusion surgery: RR 1.40</p>	<p>Literature searches were conducted up until April 2006 from AustHealth, Cinahl, Cochrane Library, Current Contents, Embase, Pre-medline, Proceedings First, Web of Science and EconLit.</p> <p>6 uncontrolled before-and-after case series (level IV interventional evidence) assessed the safety of the Dynesys device: Dubois et al. 1999, Stoll et al. 2002, Schnake et al. 2006, Bordes-Monmeneu et al. 2005, Grob et al. 2005, Putzier et al. 2004.</p> <p>2 comparative studies (level III-3 interventional evidence): Cakir et al. 2003, Putzier et al. 2005</p>

			<p>used 2 years after insertion of the Dynesys device than before in 26 patients with lumbar spinal stenosis and degenerative spondylolisthesis</p> <p>Improving quality of life</p> <p>Cakir 2003: Both the Dynesys and fusion (with decompression surgery) were effective at improving quality of life.</p> <p>Physical functioning</p> <p>Cakir 2003: Dynesys was as effective as decompression surgery with/without fusion surgery at improving patient assessed functioning. No significant difference found in Putzier 2005.</p> <p>Stoll (2002) and Bordes-Monmeneu (2005) reported an improvement in functioning after insertion of the Dynesys (statistically significant in Stoll 2002)</p> <p>Hospital stay was shorter for patients who received the Dynesys (19.3 days; range 11–28 days) than those who received fusion surgery (28.4 days; range 16–37 days), in Germany (Cakir 2003).</p>	<p>(95%CI: 0.30, 6.53).</p> <p>- decompression with fusion surgery: RR 0.50 (95%CI: 0.05, 4.67)</p> <p>2) in 6 uncontrolled case series (361 patients): minor complications occurred in up to 7.7% of patients</p> <p>Radiographic findings</p> <p>1) Cakir (2003): Dynesys with decompression vs. decompression with fusion surgery: no patients in either treatment group had any breakage or dislodgment of screws</p> <p>2) Putzier (2005): fewer complications after Dynesys plus decompression than after a nucleotomy alone (risk difference = -0.41; 95%CI - 0.55, -0.27)</p> <p>In 5 uncontrolled case series, loose screws in up to 16.7% of patients.</p> <p>No studies compare rates of screw loosening or breakage</p>	
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				<p>Reoperation rate</p> <p>In 5 uncontrolled case series, 3.8 to 12.9% of patients who received the Dynesys required reoperation at the index level.</p> <p>Conclusion: Dynesys is no more effective in selected cases than laminectomy and fusion, and requires almost the same surgical exposure</p>	<p>between Dynesys and pedicle screw systems associated with fusion surgery.</p> <p>Conclusion: Dynesys is as safe as laminectomy with spinal fusion; there is a slightly higher incidence of loosening of the pedicle screws with the use of Dynesys</p>	
Primary studies						
Lee 2008 Korea	20 consecutive patients (13 females, 7 males) with a mean age of 61±6.98 years (range 46-70). The diagnoses included spinal stenosis with degenerative spondylolisthesis (45%), degenerative spinal stenosis (25%), adjacent segmental disease after fusion (15%), spinal stenosis with degenerative scoliosis (10%) and recurrent intervertebral lumbar disc herniation (5%)	Decompression and dynamic stabilization with the Dynesys L4-5 (50%) L3-4 (40%) L5-S1 (10%)	<p>Outcomes assessment: visual analogue scale (VAS), Korean version of Oswestry disability index (ODI)</p> <p>Reducing pain</p> <p>VAS decreased from 8.55±1.21 to 2.20±1.70 (p<0.001)</p> <p>Postoperatively, 11 patients (57.8%) were completely free of back and leg pain.</p> <p>Analgesic use</p> <p>19 patients (100%) used medication preoperatively and only 5 patients (26.3%) postoperatively.</p>	<p>Complications</p> <p>There were 6 patients with dural tear during decompressive procedure, found and repaired intra operatively.</p> <p>One patient developed dysarthria and facial palsy at 8 days postoperative and was diagnosed with an acute infarction of the left corona radiata of the cerebrum.</p> <p>The implant in one patient needed to be removed due to a delayed allergic reaction 10 months after the operation.</p>	Mean follow-up period was 27.25±5.16 months (range 16-35 months), and 19 patients (95%) were available for follow-up.	

				<p>Improving functional status</p> <p>Mean score on the Korean version of the ODI improved from 79.58%±15.93% (severe disability) to 22.17%±17.24% (moderate disability) (p<0.001)</p> <p>Reoperation rate</p> <p>Two patients needed additional surgery for persistent back pain (laminectomy in 1 case, decompression and fusion in 1 case)</p>	<p>There were no implant failures, such as pedicle fracture, screw loosening or screw malposition, as of the last follow-up.</p>	
Schaeren 2008 Switzerland	26 consecutive patients (mean age, 71 years) with symptomatic lumbar spinal stenosis and degenerative spondylolisthesis	Interlaminar decompression and stabilization with Dynesys	<p>Outcomes assessment: intensity of pain according (VAS), neurologic symptoms, walking distance, analgesic, subsequent spinal surgery, activity status (Prolo Economic Scale), patient satisfaction (NASS Patient Satisfaction Index)</p> <p>Reducing Pain</p> <ul style="list-style-type: none"> - VAS: from mean 80 (range 55-100) to mean 25 (range 0-80); p<0.001 - back and leg pain: from 26 patients (100%) to 13 patients (68%); p=0.008 - use of medication: from 18 patients (69%) to 5 patients (26%); 	<p>Minor complications</p> <p>Screw loosening in 3 patients (11%)</p>	<p>Follow-up of 4 years</p> <p>19 of 26 patients were evaluated with a mean follow-up of 52 months (range, 48–57 months).</p>	

			<p>p=0.002</p> <ul style="list-style-type: none"> - use of opiates: from 6 patients (23%) to 0 patient (0%) <p>Walking</p> <ul style="list-style-type: none"> - claudication from 26 patients (100%) to 3 patients (16%); p<0.001 - walking distance from mean 250m (range 10-2000) to mean >1000m (range 100-∞); p=0.003 <p>Activity status</p> <ul style="list-style-type: none"> - 8 patients (42%): more active than before onset of symptoms - 6 patients (32%): previous level without restriction - 3 patients (16%) previous level with restriction <p>Satisfaction</p> <ul style="list-style-type: none"> - 15 patients (79%) would definitely undergo same intervention - 3 patients (16%) would probably undergo same intervention <p>Reoperation rates</p> <p>4/19 patients were re-operated during the follow-up (21%): for</p>		
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				<p>insufficient decompression (1), for osteoporotic fractures after falls (2), due to adjacent segment disability (1)</p> <p>Adjacent Level Degeneration</p> <p>New signs of degeneration adjacent to the stabilized segment in 9 patients (47%)</p>		
<p>Würgler-Hauri 2008 Switzerland</p>	<p>37 consecutive patients (mean age 58 years) with lumbar stenosis, signs of segmental instability and DDD</p>	<p>Lumbar microsurgical decompression and implantation of Dynesys</p>	<p>Outcomes assessment: visual analogue scale (VAS-100mm), distribution and severity of pain, activity status (Prolo Functional and Economic Scale), Stauffer Coventry Scale</p> <p>VAS for leg pain from 8.4±2.1 to 3.1±1.4</p> <p>VAS for back pain from 6.7±2.8 to 4±2.8</p> <p>Overall pain severity Improvement due to reduction of radicular pain from 59.2% to 27.3% after microsurgical decompression.</p> <p>Percentage of patients who are suffering at 12 months - lumbar pain deteriorated from</p>	<p>Major complications: Complications included 4 broken and 2 misplaced screws from a total of 224 screws implanted, 2 loosen systems, and 1 cerebrospinal fistula. At 1-year, a total of 7 patients (19%) required surgical revision.</p>	<p>Prospective clinical study</p> <p>Follow-up at 12 months</p> <p>No p-values were reported</p>	

				<p>40.8% to 47.8%</p> <p>- less patients described leg pain (59.2%–27.3%) after surgery</p> <p>Activity status</p> <p>51% and 54% of the patients had a Prolo Economic Status and Prolo Functional of 4 or 5, meaning working or being active at previous level with or without limitation at 12 months</p> <p>Outcome</p> <p>27% percent (patient's self-evaluation) and 29.7% (Stauffer Coventry Scale) of the patients described a fair or poor outcome.</p>		
Welch 2007 USA	101 patients (mean age of 56.3 years (range 27–79 years)) with degenerative spondylolisthesis (n=20), retrolisthesis (Grade I) or lateral or central spinal stenosis (n=26)	<p>Interlaminar decompression and stabilization with Dynesys</p> <p>L4-L5 (38%)</p> <p>L4-S1 (23%)</p> <p>L3-L5 (20%)</p>	<p>Outcomes assessment: visual analogue scale (VAS-100mm), the SF-12, Oswestry disability index (ODI), overall patient satisfaction</p> <p>Mean VAS for lower limb pain</p> <p><u>pre-op</u> <u>12mo</u></p> <p>80.3 25.5 (range 0-96; p<0.01)</p> <p>Mean VAS for back pain</p> <p><u>pre-op</u> <u>12mo</u></p> <p>54 29.4 (range 0-95; p<0.01)</p>	<p>Intra-operative complications: 16 intra-operative complications reported (15.8%): 12 were dural tears, 2 cases of excessive blood loss requiring transfusion, 1 patient suffered an allergic reaction to anaesthesia; and 1 was a fractured pedicle, which occurred during screw insertion.</p> <p>Reoperations:</p> <p>15 (15%) of 101 patients required 18 re-interventions by the time of the 1-year follow-up</p>	<p>Part of a Food and Drug Administration clinical trial.</p> <p>Non comparative, prospective clinical study</p> <p>At the 1-year follow-up visit, only 80 patients were followed</p>	

				<p>evaluation.</p> <p>10 of the 18 re-interventions were revision surgery (decompression, extension of the segmental fixation, or removal of extradural synovial facet cyst) at the same spinal level due to radiculopathy, increased back pain, or increased instability. In 3 of these 10 re-interventions, removal of the stabilization system was required.</p>	
			<p>Mean SF-12 MCS</p> <p>pre-op 12mo</p> <p>41.6 49.4 (p<0.01)</p> <p>Mean SF-12 PCS</p> <p>pre-op 12mo</p> <p>27.3 40.3 (p<0.01)</p> <p>Mean patient satisfaction (VAS-100)</p> <p>12months : 79</p> <p>Mean willingness to recommend the intervention (VAS-100)</p> <p>12 months: 73.1</p> <p>Oswestry Disability Index (mean scores)</p> <p>pre-op 12mo</p> <p>55.6% (0-94%) 26.3% (0-94%)</p> <p>No statistical differences between patients treated for one level or for two levels</p>		

^a Adverse events were classified as serious if they were likely to require hospitalisation or further surgery

APPENDIX 6: LITERATURE SEARCH STRATEGY

Date	April, 15 2009
Database	Ovid MEDLINE(R)
Date covered	1950 to Present with Daily Update
Search Strategy	<ol style="list-style-type: none"> 1 exp "costs and cost analysis"/ (140558) 2 cost of illness/ (11424) 3 exp health care costs/ (32537) 4 exp economics/ (400714) 5 value of life/ (5023) 6 exp "economics, dental"/ (3702) 7 exp "economics, hospital"/ (15853) 8 exp "economics, medical"/ (11654) 9 exp "economics, nursing"/ (3780) 10 exp "economics, Pharmaceutical"/ (2012) 11 quality-adjusted life years/ (3782) 12 models, economic/ (3459) 13 markov chains/ (5424) 14 monte carlo method/ (12154) 15 decision tree/ (6785) 16 6 or 11 or 3 or 7 or 9 or 12 or 2 or 15 or 14 or 8 or 1 or 4 or 13 or 10 or 5 (426579) 17 econom\$.tw. (104613) 18 cost\$.tw. (224337) 19 (price? or pricing?).tw. (16190) 20 (pharmacoeconomic? or (pharmaco adj economic?)).tw. (2134) 21 budget\$.tw. (12741) 22 expenditure\$.tw. (24683) 23 cea.tw. (12491) 24 cua.tw. (610) 25 cba.tw. (7601) 26 25 or 21 or 17 or 20 or 22 or 18 or 24 or 16 or 19 or 23 (668217) 27 Sciatica/ (3607) 28 Low Back Pain/ (9282) 29 Spinal Stenosis/ (2931) 30 Intermittent Claudication/ (6010) 31 Nerve Compression Syndromes/ (8109) 32 Osteoarthritis, Spine/ (2) 33 Spondylosis/ (36) 34 Spondylolisthesis/ (2939) 35 Sciatica.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (4437) 36 (back adj4 pain).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (29266) 37 spin\$.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (366177) 38 claudication.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (8762) 39 (nerve adj4 compression).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (10391) 40 (Osteoarthritis and Spin\$).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (1527) 41 Spondylosis.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (1803) 42 Spondylolisthesis.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (3490) 43 (degenerative adj4 (disc or disk) adj4 disease\$).mp. [mp=title, original

	<p>title, abstract, name of substance word, subject heading word] (846)</p> <p>44 intervertebral disk degeneration.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (41)</p> <p>45 intervertebral disc degeneration.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (294)</p> <p>46 (hernia\$ and (disc or disk)).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (6288)</p> <p>47 (facet adj4 arthr\$).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (220)</p> <p>48 or/27-47 (404372)</p> <p>49 Lumbar Vertebrae/ (28996)</p> <p>50 lumbar.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (64588)</p> <p>51 or/49-50 (64588)</p> <p>52 51 and 48 (47961)</p> <p>53 (spin\$ adj4 decompres\$).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (1477)</p> <p>54 (spin\$ adj4 stabili\$).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (2654)</p> <p>55 (pedicle adj4 screw).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (1292)</p> <p>56 (spin\$ adj4 spacer).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (27)</p> <p>57 interspinous process decompression.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (9)</p> <p>58 interspinous distraction.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (2)</p> <p>59 dynamic neutralization.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (9)</p> <p>60 dynamic neutralisation.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (2)</p> <p>61 dynamic stabilization.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (106)</p> <p>62 dynamic stabilisation.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (7)</p> <p>63 non fusion.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (174)</p> <p>64 (dynesys or dynesis or X stop or wallis or diam or coflex).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (4970)</p> <p>65 or/53-64 (10269)</p> <p>66 52 and 65 (2151)</p> <p>67 26 and 66 (64)</p>
Note	

Date	April, 15 2009
Database	Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations
Date covered	April 13, 2009
Search Strategy	<p>1 econom\$.tw. (7161)</p> <p>2 cost\$.tw. (15010)</p> <p>3 (price? or pricing?).tw. (970)</p> <p>4 (pharmacoeconomic? or (pharmaco adj economic?)).tw. (120)</p> <p>5 budget\$.tw. (809)</p> <p>6 expenditure\$.tw. (1299)</p> <p>7 cea.tw. (450)</p> <p>8 cua.tw. (20)</p> <p>9 cba.tw. (126)</p> <p>10 Sciatica.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (88)</p>

	<p>11 (back adj4 pain).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (1421)</p> <p>12 spin\$.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (22379)</p> <p>13 claudication.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (201)</p> <p>14 (nerve adj4 compression).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (163)</p> <p>15 (Osteoarthritis and Spin\$).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (34)</p> <p>16 Spondylosis.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (61)</p> <p>17 Spondylolisthesis.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (129)</p> <p>18 (degenerative adj4 (disc or disk) adj4 disease\$).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (61)</p> <p>19 intervertebral disk degeneration.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (3)</p> <p>20 intervertebral disc degeneration.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (47)</p> <p>21 (hernia\$ and (disc or disk)).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (277)</p> <p>22 (facet adj4 arthr\$).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (14)</p> <p>23 Lumbar Vertebrae/ (0)</p> <p>24 lumbar.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (2446)</p> <p>25 (spin\$ adj4 decompres\$).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (88)</p> <p>26 (spin\$ adj4 stabili\$).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (231)</p> <p>27 (pedicle adj4 screw).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (141)</p> <p>28 (spin\$ adj4 spacer).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (6)</p> <p>29 interspinous process decompression.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (0)</p> <p>30 interspinous distraction.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (0)</p> <p>31 dynamic neutralization.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (0)</p> <p>32 dynamic neutralisation.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (0)</p> <p>33 dynamic stabilization.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (19)</p> <p>34 dynamic stabilisation.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (2)</p> <p>35 non fusion.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (18)</p> <p>36 (dynesys or dynesis or X stop or wallis or diam or coflex).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (471)</p> <p>37 or/1-9 (23088)</p> <p>38 or/10-22 (23873)</p> <p>39 or/23-24 (2446)</p> <p>40 or/25-36 (936)</p> <p>41 and/37-40 (5)</p>
Note	

Date	January, 09 2009
Database	Ovid Econlit
Date covered	1969 to March 2009
Search Strategy	<ol style="list-style-type: none"> 1 econom\$.tw. (231860) 2 cost\$.tw. (71324) 3 (price? or pricing?).tw. (82989) 4 (pharmacoeconomic? or (pharmaco adj economic?)).tw. (227) 5 budget\$.tw. (12488) 6 expenditure\$.tw. (14958) 7 cea.tw. (81) 8 cua.tw. (12) 9 cba.tw. (111) 10 Sciatica.mp. [mp=heading words, abstract, title, country as subject] (1) 11 (back adj4 pain).mp. [mp=heading words, abstract, title, country as subject] (20) 12 spin\$.mp. [mp=heading words, abstract, title, country as subject] (666) 13 claudication.mp. [mp=heading words, abstract, title, country as subject] (1) 14 (nerve adj4 compression).mp. [mp=heading words, abstract, title, country as subject] (0) 15 (Osteoarthritis and Spin\$.mp. [mp=heading words, abstract, title, country as subject] (0) 16 Spondylosis.mp. [mp=heading words, abstract, title, country as subject] (0) 17 Spondylolisthesis.mp. [mp=heading words, abstract, title, country as subject] (0) 18 (degenerative adj4 (disc or disk) adj4 disease\$.mp. [mp=heading words, abstract, title, country as subject] (0) 19 intervertebral disk degeneration.mp. [mp=heading words, abstract, title, country as subject] (0) 20 intervertebral disc degeneration.mp. [mp=heading words, abstract, title, country as subject] (0) 21 (hernia\$ and (disc or disk)).mp. [mp=heading words, abstract, title, country as subject] (1) 22 (facet adj4 arthr\$.mp. [mp=heading words, abstract, title, country as subject] (0) 23 [Lumbar Vertebrae/] (0) 24 lumbar.mp. [mp=heading words, abstract, title, country as subject] (3) 25 (spin\$ adj4 decompres\$.mp. [mp=heading words, abstract, title, country as subject] (0) 26 (spin\$ adj4 stabili\$.mp. [mp=heading words, abstract, title, country as subject] (0) 27 (pedicle adj4 screw).mp. [mp=heading words, abstract, title, country as subject] (0) 28 (spin\$ adj4 spacer).mp. [mp=heading words, abstract, title, country as subject] (0) 29 interspinous process decompression.mp. [mp=heading words, abstract, title, country as subject] (0) 30 interspinous distraction.mp. [mp=heading words, abstract, title, country as subject] (0) 31 dynamic neutralization.mp. [mp=heading words, abstract, title, country as subject] (0) 32 dynamic neutralisation.mp. [mp=heading words, abstract, title, country as subject] (0) 33 dynamic stabilization.mp. [mp=heading words, abstract, title, country as subject] (3) 34 dynamic stabilisation.mp. [mp=heading words, abstract, title, country as subject] (3)

	<p>35 non fusion.mp. [mp=heading words, abstract, title, country as subject] (0)</p> <p>36 (dynesys or dynesis or X stop or wallis or diam or coflex).mp. [mp=heading words, abstract, title, country as subject] (83)</p> <p>37 or/1-9 (341610)</p> <p>38 or/10-22 (687)</p> <p>39 or/23-24 (3)</p> <p>40 or/25-36 (89)</p> <p>41 and/37-40 (0)</p>
Note	

Date	April,15 2009
Database	Ovid PsycINFO
Date covered	1987 to April Week 1 2009
Search Strategy	<p>1 econom\$.tw. (39195)</p> <p>2 cost\$.tw. (34681)</p> <p>3 (price? or pricing?).tw. (5535)</p> <p>4 (pharmacoeconomic? or (pharmaco adj economic?)).tw. (211)</p> <p>5 budget\$.tw. (2711)</p> <p>6 expenditure\$.tw. (3336)</p> <p>7 cea.tw. (316)</p> <p>8 cua.tw. (15)</p> <p>9 cba.tw. (299)</p> <p>10 Sciatica.mp. [mp=title, abstract, heading word, table of contents, key concepts] (42)</p> <p>11 (back adj4 pain).mp. [mp=title, abstract, heading word, table of contents, key concepts] (2434)</p> <p>12 spin\$.mp. [mp=title, abstract, heading word, table of contents, key concepts] (11518)</p> <p>13 claudication.mp. [mp=title, abstract, heading word, table of contents, key concepts] (52)</p> <p>14 (nerve adj4 compression).mp. [mp=title, abstract, heading word, table of contents, key concepts] (52)</p> <p>15 (Osteoarthritis and Spin\$).mp. [mp=title, abstract, heading word, table of contents, key concepts] (12)</p> <p>16 Spondylosis.mp. [mp=title, abstract, heading word, table of contents, key concepts] (25)</p> <p>17 Spondylolisthesis.mp. [mp=title, abstract, heading word, table of contents, key concepts] (3)</p> <p>18 (degenerative adj4 (disc or disk) adj4 disease\$).mp. [mp=title, abstract, heading word, table of contents, key concepts] (6)</p> <p>19 intervertebral disk degeneration.mp. [mp=title, abstract, heading word, table of contents, key concepts] (1)</p> <p>20 intervertebral disc degeneration.mp. [mp=title, abstract, heading word, table of contents, key concepts] (2)</p> <p>21 (hernia\$ and (disc or disk)).mp. [mp=title, abstract, heading word, table of contents, key concepts] (59)</p> <p>22 (facet adj4 arthr\$).mp. [mp=title, abstract, heading word, table of contents, key concepts] (0)</p> <p>23 Lumbar Vertebrae/ (0)</p> <p>24 lumbar.mp. [mp=title, abstract, heading word, table of contents, key concepts] (1377)</p> <p>25 (spin\$ adj4 decompres\$).mp. [mp=title, abstract, heading word, table of contents, key concepts] (9)</p> <p>26 (spin\$ adj4 stabili\$).mp. [mp=title, abstract, heading word, table of contents, key concepts] (40)</p> <p>27 (pedicle adj4 screw).mp. [mp=title, abstract, heading word, table of</p>

	<p>contents, key concepts] (1)</p> <p>28 (spin\$ adj4 spacer).mp. [mp=title, abstract, heading word, table of contents, key concepts] (0)</p> <p>29 interspinous process decompression.mp. [mp=title, abstract, heading word, table of contents, key concepts] (0)</p> <p>30 interspinous distraction.mp. [mp=title, abstract, heading word, table of contents, key concepts] (0)</p> <p>31 dynamic neutralization.mp. [mp=title, abstract, heading word, table of contents, key concepts] (0)</p> <p>32 dynamic neutralisation.mp. [mp=title, abstract, heading word, table of contents, key concepts] (0)</p> <p>33 dynamic stabilization.mp. [mp=title, abstract, heading word, table of contents, key concepts] (5)</p> <p>34 dynamic stabilisation.mp. [mp=title, abstract, heading word, table of contents, key concepts] (0)</p> <p>35 non fusion.mp. [mp=title, abstract, heading word, table of contents, key concepts] (0)</p> <p>36 (dynesys or dynesis or X stop or wallis or diam or coflex).mp. [mp=title, abstract, heading word, table of contents, key concepts] (386)</p> <p>37 or/1-9 (77879)</p> <p>38 or/10-22 (13782)</p> <p>39 or/23-24 (1377)</p> <p>40 or/25-36 (439)</p> <p>41 and/37-40 (1)</p>
Note	

Date	April, 15 2009
Database	Cochrane Library: Cochrane Database of systematic reviews, DARE, Cochrane Central Register of Controlled Trials, HTA, NHS EED, Cochrane groups and Methods studies.
Date covered	
Search Strategy	<p>#1 MeSH descriptor Economics explode all trees 27779</p> <p>#2 MeSH descriptor Costs and Cost Analysis explode all trees 26030</p> <p>#3 (cost):ti,ab,kw or (costs):ti,ab,kw or (costing):ti,ab,kw 37237</p> <p>#4 (econom*):ti,ab,kw or (pharmacoeconom*):ti,ab,kw 30805</p> <p>#5 (#1 OR #2 OR #3 OR #4) 42765</p> <p>#6 MeSH descriptor Sciatica explode all trees 162</p> <p>#7 MeSH descriptor Low Back Pain explode all trees 1267</p> <p>#8 MeSH descriptor Spinal Stenosis explode all trees 70</p> <p>#9 MeSH descriptor Intermittent Claudication explode all trees 607</p> <p>#10 MeSH descriptor Nerve Compression Syndromes explode all trees 354</p> <p>#11 MeSH descriptor Spinal Diseases explode all trees 1560</p> <p>#12 MeSH descriptor Spondylolisthesis explode all trees 48</p> <p>#13 (sciatica):ti,ab,kw or (spin*):ti,ab,kw or (back pain):ti,ab,kw or (claudication):ti,ab,kw or (nerve compression):ti,ab,kw or (spondylosis):ti,ab,kw or (spondylolisthesis):ti,ab,kw or (degenerative disc disease):ti,ab,kw or (degenerative disk disease):ti,ab,kw or (intervertebral disc degeneration):ti,ab,kw or (intervertebral disk degeneration):ti,ab,kw or (disc hernia):ti,ab,kw or (disk hernia):ti,ab,kw 14659</p> <p>#14 (#6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13) 15460</p> <p>#15 MeSH descriptor Lumbar Vertebrae explode all trees 1329</p> <p>#16 (lumbar):ti,ab,kw 4337</p> <p>#17 (#15 OR #16) 4337</p> <p>#18 (#14 AND #17) 3263</p> <p>#19 (pedicle screw):ti,ab,kw or (interspinous process decompression):ti,ab,kw or (interspinous distraction):ti,ab,kw or (dynamic neutralization):ti,ab,kw or (dynamic neutralisation):ti,ab,kw or (dynamic stabilization):ti,ab,kw or (dynamic stabilisation):ti,ab,kw or (interspinous device):ti,ab,kw or (interspinous</p>

	spacer):ti,ab,kw or (non fusion):ti,ab,kw or (dynesys):ti,ab,kw or (dynesis):ti,ab,kw or (X stop):ti,ab,kw or (wallis):ti,ab,kw or (diam):ti,ab,kw or (coflex):ti,ab,kw 927 #20 (#18 AND #19) 105 #21 (#5 AND #20) 13
Note	Cochrane Database of Systematic Reviews [0] Database of Abstracts of Reviews of Effects [0] Cochrane Central Register of Controlled Trials [8] Methods Studies [0] Health Technology Assessment Database [0] NHS Economic Evaluation [5] Cochrane Groups [0].

Date	April, 14 2009
Database	Embase
Date covered	1974 to present
Search Strategy	<p>#1. ('health economics'/exp OR 'health economics') OR ('health care cost'/exp OR 'health care cost') OR ('economic evaluation'/exp OR 'economic evaluation') OR ('pharmacoeconomics'/exp OR 'pharmacoeconomics') OR ('health care cost'/exp OR 'health care cost') OR (expenditure*:ab,ti NOT energy:ab,ti) OR (econom*:ab,ti OR cost:ab,ti OR costs:ab,ti OR costly:ab,ti OR costing:ab,ti OR price:ab,ti OR prices:ab,ti OR pricing:ab,ti OR pharmacoeconomic*:ab,ti) OR (budget*:ab,ti) OR ('value *2 money') 684,058</p> <p>#2. 'ischialgia'/exp 4,472</p> <p>#3. 'low back pain'/exp 22,266</p> <p>#4. 'vertebral canal stenosis'/exp 4,285</p> <p>#5. 'intermittent claudication'/exp 6,920</p> <p>#6. 'nerve compression'/exp 9,169</p> <p>#7. 'spondylarthritis'/exp 275</p> <p>#8. 'spondylosis'/exp 4,381</p> <p>#9. 'spondylolisthesis'/exp 3,718</p> <p>#10. 'intervertebral disk disease'/exp 18,259</p> <p>#11. 'intervertebral disk degeneration'/exp 3,245</p> <p>#12. 'intervertebral disk hernia'/exp 13,780</p> <p>#13. 'zygapophyseal joint'/exp 400</p> <p>#14. 'spine disease'/exp 101,586</p> <p>#15. #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 135,375</p> <p>#16. 'lumbar spine'/exp 18,327</p> <p>#17. 'lumbar vertebra'/exp 12,493</p> <p>#18. 'lumbar' 76,044</p> <p>#19. #16 OR #17 OR #18 76,044</p> <p>#20. #15 AND #19 27,515</p> <p>#21. (interspinous AND (implant* OR device* OR distract*)) 117</p> <p>#22. ((dynamic OR elastic) AND (neutrali?ation OR stabil?ation)) 2,124</p> <p>#23. 'non fusion' OR dynesys OR dynesis OR 'x stop' OR wallis OR coflex OR diam 8,559</p> <p>#24. #21 OR #22 OR #23 10,714</p> <p>#25. #1 AND #20 AND #24 10</p>
Note	

APPENDIX 7: DATA EXTRACTION FORM

Authors (Year)	Kondrashov DG, Hannibal M, Hsu KY, Zucherman JF (2007).
Funding	St. Mary's Spine Center.
Country	USA.
Design	Retrospective study.
Perspective	Not specified (Health care payer).
Time window	Cost: hospitalization / Outcomes: 51.3 months for the "X Stop" group and 51.8 months for the group "decompression surgery".
Interventions	X STOP Interspinous Process Decompression (IPD) (n=18 patients) versus decompression without fusion (laminectomy, hemilaminectomy, laminotomy, or foraminotomy; alone or in combination) (n=12 patients).
Population	Patients with lumbar spinal stenosis. Inclusion criteria: at least 50 years old; with leg, buttock, or groin pain during flexion, able to walk at least 50 feet and sit comfortably for 50 min. Exclusion criteria: fixed motor deficit, cauda equina syndrome, previous lumbar surgery of the stenotic level or spondylolisthesis greater than grade I at the affected level.
Assumptions	An absolute improvement of 15 ODI points was selected to define an individual patient success.
Data source for costs	This retrospective study (2000-2001).
Cost items included	(\$2000-2001). Direct health care fees for the hospitalization (In-hospital stay, laboratory, imaging, anesthesia, medications, operative room charges, implant (X stop), and other).
Data source for outcomes	This retrospective study (begin in 2000-2001).
Discounting	Not specified (no discounting).
Costs	For 1 level: X stop: \$15 980 / Decompression surgery: \$45 302 / incremental cost = \$29 322 (p<0.001) / For 2 levels: X stop: \$25 618 / Decompression surgery: \$46 752 / incremental cost = \$21 134 (p<0.001).
Outcomes	Success rate: X stop: 78% / Decompression surgery: 33% / Incremental efficacy = 45% (p = 0.0243).
Cost-effectiveness	Not appropriate (different time frame).
Sensitivity analysis	Not conducted.
Conclusions	Authors concluded that IPD with X STOP for the treatment of lumbar spinal stenosis was clinically at least as effective as standard laminectomy at 4 years and that hospitalization costs were lower (X stop = cost-saving strategy). The primary cost drivers were the in-hospital stay, anesthesia, and operating room charges due to the fact that X stop IPD was a less invasive technique (lower length of stay and lower operative time).
Remarks	1) The sample size was small: only 30 patients 2) They used hospital charges and do not estimate the real cost 3) Inclusion criteria were strict. Consequently, they do not assess the efficiency of the procedure in the real practice. 4) This was a retrospective study and not a randomized double blinded clinical trial. Thus, selection bias was possible. Moreover, authors specified that the population has multiple comorbidities but no description and comparisons of comorbidities between groups were done. 5) They only assess direct cost during the hospitalization. A longer timeframe is needed. 6) P-values were given but not the 95% confidence intervals. 7) The outcome was not appropriate. They only measure an intermediary outcome in terms of success rate (improvement of 15 ODI points) and not the life expectancy or the impact on the quality adjusted life year (QALY). 8) They do not compare X STOP IPD with all relevant alternatives (e.g. other surgery procedure with spinal non fusion interspinous implant or conservative non surgical treatment) 9) Results are not transferable to our country setting (X STOP = Patients treated under local anaesthesia on an outpatient basis).

Authors (Year)	Medical Services Advisory Committee (MSAC) (2008).
Funding	MSAC.
Country	Australia.
Design	Cost analysis.
Perspective	Health care payer.
Time window	Hospitalization (5.47-13.6 days).
Interventions	1) Decompression alone / 2) Decompression + fusion / 3) Decompression + interspinous devices (DIAM, Wallis, Coflex, X STOP) / 4) Decompression + non fusion pedicle screw device (Dynesys).
Population	Patients with symptomatic lumbar spinal stenosis, degenerative spondylolisthesis, herniated disc or facet joint osteoarthritis.
Assumptions	1) Patients receive the more common form of decompression: i.e. laminectomy for 1 level recurrent disc lesion or spinal stenosis and laminectomy for spinal stenosis involving more than 1 vertebral interspace. 2) The pre-procedural work-up is assumed to be similar between groups and was thus not measured. 3) 65% = 1 level; 20% = 2 levels; 10% = 3 levels; 5% = 4 levels. 4) 27% are aged 70 years or greater. 5) All patients undergo rhizolysis as part of the decompression surgery. 6) For laminectomy, 65% of patients had fluoroscopy for less than 1 hour. 7) Unit cost of inserting a non-fusion interspinous device is estimated from the Medical benefit Schedule (MBS) item 48678 (simple internal fixation of Spine). 8) Unit cost of inserting a non-fusion pedicle screw device (Dynesys) is estimated from the Medical benefit Schedule (MBS) items 48642 (segmental internal fixation for 1 or 2 levels) and 48675 (segmental internal fixation for 1 or 2 levels). 9) For fusion, 30% of patients received bone graft substitute and bone morphogenetic proteins and 26% of patients received a cage. 10) Authors assumed that the length of the in-hospital stay and the cost of the in-hospital stay for the insertion of a non fusion interspinous device were equal to an in-hospital stay for decompression alone (Proxy used: 110 other back and neck procedures); and that the length of an in-hospital stay and the cost of an in-hospital stay for the insertion of a non fusion pedicle screw device were equal to an in-hospital stays for decompression and fusion (Proxy used: 109A spinal fusion).
Data source for costs	Australian government: Schedule of Medicare Benefits (2005) and Round 7 Cost Report AR-DRG for private hospitals (2003-4); Australian Health Insurance Association: Prosthesis list (2005); Zimmer Spine; and Taylor Bryant; Putzier 2005.
Cost items included	(Australian \$ 2006). Direct health care fees (Medical practitioner fees for anesthesia, surgery, assistance and imaging; prostheses costs; and other hospital and theatre accommodation costs). Indirect costs (i.e. time and productivity losses) were not included.
Data source for outcomes	NA
Discounting	NA
Costs	1) Decompression alone: \$7689 / 2) Decompression + fusion: \$26197 / 3) Decompression + interspinous devices (DIAM, Wallis, Coflex, X STOP) : \$14882 / 4) Decompression + non fusion pedicle screw device (Dynesys) : \$22241.
Outcomes	NA
Cost-effectiveness	NA
Sensitivity analysis	Not performed
Conclusions	The cost of decompression with the insertion of a non fusion device is higher than the cost of decompression surgery alone mostly because of the cost of the device itself, but is lower than decompression surgery and fusion.

Remarks

1) Most estimates for non fusion surgery were based on proxy and assumptions. Medical practitioner fees were estimated from MBS items of Medicare Australia. For the insertion of non fusion interspinous or pedicle screw devices, no specific item existed and proxies were used (48678; 48642; 48675). For other hospital and accommodation costs, the cost for decompression surgery alone and for decompression surgery with insertion of an interspinous device were assumed to be equal and were estimated using the proxy I10 "Other back and Neck procedures", which is not specific to decompression surgery. Moreover, the cost of decompression surgery with insertion of a non fusion pedicle screw (Dynesys) device was assumed to be equal to the cost of decompression surgery and fusion.

2) Authors explained that the societal perspective was chosen but they do not included indirect costs (only direct hospital fees were assessed => health care payer perspective). 3) The cost of non fusion interspinous devices could only be compared to the cost of decompression surgery alone. Surgery with fusion concerned other indications. 4) Long term consequences were not assessed. 5) Separate analysis for each device should have been interesting 6) Uncertainty was not handled by sensitivity analyses.

APPENDIX 8: QUALITY ASSESSMENT CHECKLIST

Study design	Kondrashov	MSAC
The research question is stated	Yes	Yes
The economic importance of the research question is stated	Partially	Partially
The viewpoints of the analysis are clearly stated and justified	No	Yes
The rationale for choosing the alternative programmes or interventions compared is stated	No	Yes
The alternatives being compared are clearly described	Sources were given	Yes
The form of economic evaluation used is stated	No	Yes
The choice of form of economic evaluation is justified in relation to the questions addressed	No	No

Data collection	Kondrashov	MSAC
The sources of effectiveness estimates used are stated	Yes	NA
Details of the design and results of effectiveness study are given (if based on a single study)	Yes	NA
Details of the method of synthesis or meta-analysis of estimates are given (if based on an overview of a number of effectiveness studies)	NA	NA
The primary outcome measure(s) for the economic evaluation are clearly stated	Yes	NA
Methods to value health states and other benefits are stated	Yes	NA
Details of the subjects from whom evaluations were obtained are given	Partially	Partially
Productivity changes (if included) are reported separately	NA	NA
The relevance of productivity changes to the study question is discussed	Yes	No
Quantities of resources are reported separately from their unit costs	No	No
Methods for the estimation of quantities and unit costs are described	No	Yes
Currency and price data are recorded	Partially	Yes
Details of currency or price adjustments for inflation or currency conversion are given	No	Yes
Details of any model used are given	NA	NA
The choice of model used and the key parameters on which it is based are justified	NA	NA

Analysis and interpretation of results	Kondrashov	MSAC
Time horizon of costs and benefits is stated	Yes	Yes
The discount rate(s) is stated	NA	NA
The choice of rate(s) is justified	NA	NA
An explanation is given if costs or benefits are not discounted	NA	NA
Details of statistical tests and confidence intervals are given for stochastic data	Partially	No
The approach to sensitivity analysis is given	No	No
The choice of variables for sensitivity analysis is justified	NA	NA
The ranges over which the variables are varied are stated	NA	NA
Relevant alternatives are compared	No	Partially
Incremental analysis is reported	No	Yes
Major outcomes are presented in a disaggregated as well as aggregated form	Yes	Yes

The answer to the study question is given	Yes	Partially (based on proxy and estimates)
Conclusion follow from the data reported	Yes	Yes
Conclusions are accompanied by the appropriate caveats	Partially	No

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