Minimal Access Spinal Surgery

Why minimal access surgery?

Minimal access spinal surgery (MASS) has been developed with the aim of reducing approach-related morbidity or 'collateral damage' to surrounding tissues whilst obtaining the same clinical outcomes of traditional open procedures. The procedure has been developed to complement minimal invasive spinal surgery (MISS) as the latter does not allow for direct visualisation of the spine. In that regard these two techniques DO NOT alter the indications or goals of surgery. The benefits of MASS include:

- reduced blood loss
- reduced post-operative incisional pain
- minimised respiratory difficulties
- improved mobilization
- early discharge from hospital
- enhanced rehabilitation and early return to activities and work.

These advantages afford a clear reduction in direct and indirect health care costs when employing MISS or MASS techniques.

What are the basic requirements?

Essential equipment includes an image guidance device, modified instruments, a light source (direct light or endoscopic assisted) and an optional access portal. The two main methods of image guidance used are fluoroscopy and computer assisted frameless spinal stereotaxy or more commonly known as computer assisted operative surgery (CAOS). Fluoroscopy has the advantage that it is relatively inexpensive, widely available, simple to use and provides immediate imaging feedback which may be in multiple planes. Its main disadvantage is the increased risk of radiation exposure.

CAOS remains expensive technology because of costly hardware and software, but the principal benefit is the limitation of radiation exposure. CAOS requires the use of a dynamic reference array that is typically attached to both the spine and the base of modified instruments (Fig 3). Recent significant advances in computer software technology, modification of specialized instruments and enhanced metallurgy of implants have greatly improved the precision of pedicle screw insertion to within sub-millimeter accuracy. Additionally, CAOS has the unique ability to educate surgeons regarding the quality of their technique and therefore allow for the improvement of accuracy and reproducibility of the surgical procedure.

Different Types Of Spinal Devices

When the anterior spine is approached and exposed, a complete discectomy and/or vertebral body excision (or corpectomy) is performed followed by the placement of an interbody device. In patients with disabling low back pain secondary to disc degeneration, FDA approved motion preserving devices or total disc replacements, (e.g. the Charite III from Depuy, Johnson and Johnson, and the

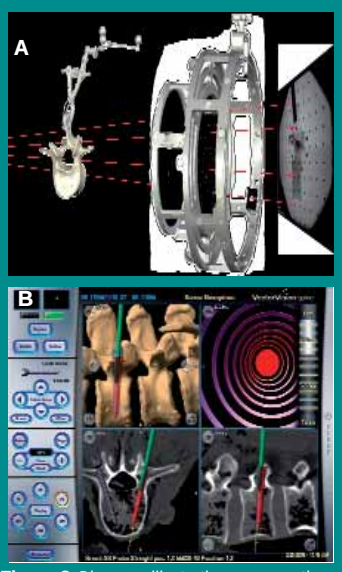
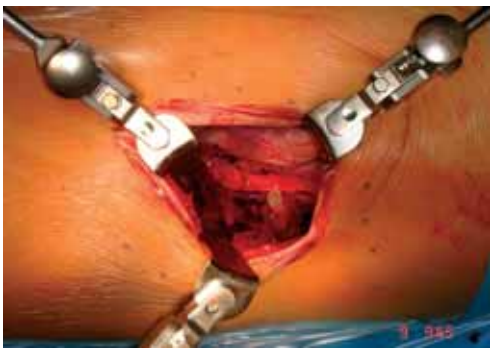


Figure 3. Diagrams illustrating pre-operative fluoroscopic registration of the spine (A) and the insertion of pedicle screws using three-dimensional navigation (B) during computer assisted operative surgery (BrainLab VectorVision Spine™ system).

How is it performed and what are the indications for its use?

Depending of the pathology being treated, a mini-open exposure minimizes the size of the wound to approximately 3 cms to 8 cms long, and with the aid of a self retaining frame-based retractor (e.g. SynFrame™, Synthes-Stratec, Switzerland), allows for a complete exposure of the desired area of the spine (**Fig. 1**). This can be performed via a direct posterior, anterior, anterolateral or combined antero-posterior approach. Both the thoracic and lumbar spine can be approached with relative ease. Common conditions that are being routinely treated using MASS include: Anterior or posterior spinal fusion for back pain from disc degeneration; sciatica from prolapsed intervertebral disc or stenosis; infection; acute traumatic fractures and post-traumatic kyphosis; metastatic tumour; spinal deformity, e.g. scoliosis (**Fig 2**) and kyphosis.



Figures 1a and b. The SynFrame™, a frame-based retractor system, allowing mini-open incisions compared to traditional retractors. This example shows the use of the SynFrame™ to perform a minimal access lateral approach to the thoraco-lumbar spine.

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Prodisc-L from Synthes-Stratec Switzerland), are being routinely used to successfully treat this condition.

Interbody fusion devices range from autograft, allograft (e.g. femoral ring), titanium or polyetheretherketone cages (expandable or non-expandable) and newer hybrid titanium-PEEK cages. These are then filled with either autograft, allograft, bone extenders (e.g. demineralised bone matrix) or bone substitutes (e.g. recombinant bone morphogenic protein or rhBMP-2 or Inductos™ [Medtronic Inc., Minneapolis, MN]). The device is inserted into the defect followed by the placing of a locking metal plate or rod. The rod spans and therefore neutralizes the compressive forces across the interbody device thus allowing fusion to occur. The development of cannulated systems and image guidance has allowed for the ease of insertion of locking screws to hold the metal plate or rod rigidly against the spine. Cannulated screws are inserted over carefully placed K-wires. This requires meticulous planning and the surgeon needs to possess superior three-dimensional spatial awareness.

Figure 2a and b. Antero-posterior plain radiographs of the whole spine showing a successful anterior scoliosis correction and fusion using MASS technique. **Fig 2c** shows the well-healed 10 centimeter wound.

Supplementary posterior fixation may be required in select cases where improved biomechanics is essential to restore disrupted posterior bony tension band structures such as in junctional areas (e.g. thoraco-lumbar junction), multi-level surgery, or osteoporotic spine. This proceedure can be performed using MASS or MISS techniques.

Spinal Fusion

The two main techniques for posterior percutaneous spinal fixation are pedicle screws and facet screws. When treating lumbar degenerative disc disease, both techniques have been developed to compliment anterior lumbar interbody fusion (ALIF) in order to perform a circumferential or 360 degree fusion with minimal patient morbidity. Currently the most widely used percutaneous pedicle screw system is the Sextant™ (Medtronic Inc., Minneapolis, MN) (Fig 4), but many other systems are now commercially available for screw insertion either percutaneously or using MASS techniques.

MASS techniques are also being increasingly practiced when performing posterior lumbar interbody fusions (PLIF) and transforaminal interbody fusions (TLIF). An access portal consisting of a tubular retractor (e.g. Quadrant™, Medtronic Inc, Minneapolis MN) is used in a minimal access muscle splitting approach (Fig 5). Direct visualization can be accomplished using a surgical microscope, endoscope or loupes. The access channel created then allows for an effortless insertion of pedicle screws and interbody cages with minimal disruption to the posterior lumbar tissues.

Decompression of lumbar spinal stenosis and disc herniations can also be easily performed using tubular retractors, (e.g. METRx™, Medtronic Inc, Minneapolis MN) (Fig 6). The blunting of modified sharp instruments allows the surgeon to slip past the nerve root whilst minimizing soft tissue retraction.

Figure 4. Diagrammatic representation of the Sextant™ system for insertion of percutaneous pedicle screws during spinal fusion.

Specialized specialists

Only surgeons competent in MASS should perform these techniques because catastrophic complications can occur from injury to the abdominal viscera, blood vessels and neurological structures.

An aspiring spinal surgeon must be able to master the conventional open technique before embarking on MASS techniques. Akin to MISS, MASS also has a relatively steep learning curve and the potential for complications remains identical to that of conventional open approaches. In addition to the need to possess inherent three-dimensional spatial awareness, the surgeon must undergo mandatory training and certification in recognised cadaver courses in order to master the hand-eye co-ordination tasks required.

Figure 5. The Quadrant™ retractor system used to minimise collateral soft tissue damage and allows insertion of pedicle screws and interbody cages for spinal fusion.

As indicated, meticulous planning and thorough knowledge of the surgical anatomy and equipment is essential for achieving success in MASS.

In carefully selected patients, a more experienced surgeon will realise and appreciate the intricacies of a well executed MASS, often being rewarded by patients who will enjoy a marked reduction in approach-related post-operative pain, hospital stay and post-operative rehabilitation.

Figure 6. The METRx™ tubular retractor system held by a flexible stainless steel arm prior to the execution of a minimally invasive lumbar discectomy.