

ORIGINAL ARTICLE

Applications of the ultrasonic bone cutter in spinal surgery – our preliminary experience

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Abstract

Objective. To present our experience with the Misonix Ultrasonic Bone scalpel in spinal surgery, highlighting its potential applications and advantages. **Methods.** Between March and December 2011, a total of 937 spinal cases were performed at a single centre. The Misonix Bone Scalpel (MBS) was used in 62 of these cases. Data were collected prospectively using the Spine Tango registry. Patient demographics, disease type, surgery performed and complications were all recorded along with pre- and post-operative core measures outcome index (COMI). **Results.** The majority of cases were for spinal degenerative disorders, in particular, revision cases. The bone cutter was also used to achieve laminotomies for access to intradural tumours, corpectomies and a mixture of other pathologies. Of the 62 patients only 1 (1.6%) experienced a blood loss greater than 500 ml, and there was only 1 dural tear (1.6%) as a direct result of the MBS. Four illustrative cases are discussed. **Conclusions.** The MBS is a useful adjunct in spinal surgery with particular value in revision cases where scar tissue distorts the normal anatomy. There was a low complication rate with a trend to reduced blood loss. This was most apparent to the senior authors during cervical and thoracic corpectomies.

Keywords: laminectomy; spinal; surgical procedure; surgery timing; surgical approach; thoracic discectomy

Introduction

The development of high-speed drills has greatly advanced spinal surgery in recent years. However even when using diamond burrs, the proximity of spinning parts to structures such as nerves, vessels and dura maters along with the associated heat damage to the surrounding tissues can limit their use or result in iatrogenic injury. There is also a risk of moving parts catching hold of swabs and cotton patties (grabbing), frequent interruption for irrigation and suctioning is often required.¹

Ultrasonic devices originally developed for dentistry first appeared in 1952 and were quickly adapted, and their use was expanded. By the 1970s the technology allowed for effective debulking and removal of soft-tissue tumours.² Adaptations of this technology have developed enabling bone dissection with a narrow cutting blade, which has the advantage of reducing bone debris.³

The Misonix Bone Scalpel™ (MBS) has recently been introduced in the UK and is designed for precise removal of rigid bone whilst remaining atraumatic to elastic, soft tissues.⁴ The hand piece conveys the irrigation which is emitted from the jet nozzle, built into the interchangeable tips (Fig. 1). The tip of the instrument oscillates⁵ at the frequency of ultrasound, and uses a piezoelectric transducer to convert electrical signal into a mechanical vibration. Micro movements are produced at the frequency of 22.5 kHz which results in only mineralised tissue being cut.⁴

Clinical materials and methods

From March to December 2011, the MBS with SonicOne® technology was used in 62 spinal surgery cases. The surgical device used at our unit comprised a power supply with a footplate, and a straight hand piece. Data from each case were collected prospectively using the Spine Tango registry with patient demographics, disease type, surgery performed and complications recorded.

Results

The MBS role in these cases was as follows:

- Primary lumbar laminectomy in 22 cases (35%), 8 primary lumbar foraminotomies (13%).
- Revision lumbar laminectomy in 9 (15%). Revision lumbar foraminotomy/discectomy in 4 cases (6%).
- Facetectomies for 5 cases in association with Transforaminal Lumbar Interbody Fusions (TLIF).
- Laminoplasty: 4 cervical, 2 thoracic and 1 lumbar.



Fig. 1. Courtesy of Misonix™.

- Two cervical corpectomies. One trench thoracic vertebrectomy for excision of a calcified thoracic disc.
- Laminectomy for access to intradural tumours: 1 thoracic and 1 cervical.
- Posterior cervical foraminotomy for two patients.

There was one case of blood loss greater than 500 ml (1.6%). There were four iatrogenic dural lesions (6.5%), three of which were as a result of bone punches and one was caused by the MBS (1.6%). Two patients developed wound infections (3.2%). Two patients who underwent surgery for intramedullary tumours exhibited worsening of neurology unrelated to the bone scalpel, and one patient undergoing laminoplasty suffered a C5 root lesion, which recovered over a few weeks, again unrelated to the MBS.

Illustrative cases

Case 1

A 60-year-old female patient presented with a 2-year history of severe left leg pain associated with paraesthesia. MRI scans revealed left L4/5 foraminal and lateral recess stenosis secondary to marked facet hypertrophy and moderate disc bulge at L4/5.

A left L5 foraminotomy was performed. Undercutting with upcut punches may be more traumatic to the nerve root considering the significant facet size. The MBS enabled good access and decompression of the nerve root as shown below (Fig. 2).

Case 2

A 50-year-old female presented with a 6-month history of bilateral leg pain with myelopathic signs. Imaging revealed a giant calcified thoracic disc occupying more than 40% of the canal at T8/9 (Fig. 3).

Following a left-sided thoracotomy, the MBS was used to perform a trench vertebrectomy (Fig. 3). Excision of giant calcified thoracic discs is known to be associated with possible significant blood loss.^{6,7} This can mandate the ligation of at least two radicular arteries above and below the disc space.

The use of the bone cutter appears to allow preservation of the radicular arteries. This reduces the risk of spinal cord infarction by avoiding the need to ligate the artery of Adamkiewicz. In our opinion, the actual vertebrectomy is performed with less blood loss and at greater speed with the aid of a bone cutter.

Case 3

A 64-year-old female presented with a history of recurrent synovial cysts at L4/5 which had been removed on three previous occasions. Her scans (Fig. 4) show a Grade 1 degenerative spondylolisthesis at L4/5.

A revision L4 laminectomy and excision of facet cyst were performed using the MBS with an L4/5 posterolateral instrumented fusion (Fig. 4). A good decompression was achieved and a CSF leak was avoided, despite significant scar tissue being present. In this case, the bone cutter reduced the time to decompress a severely stenotic canal.

Case 4

A 66-year-old lady presented with a 6-week history of progressive cervical myelopathy. Imaging revealed a C3 on C4 anterolisthesis with significant cord compression and cord signal change at this level (Fig. 5). A two-stage procedure was performed: C4 vertebrectomy with insertion of an expandable cage and C3–C5 anterior plating (Fig. 5). The second stage consisted of C2–C6 posterior cervical fixation.

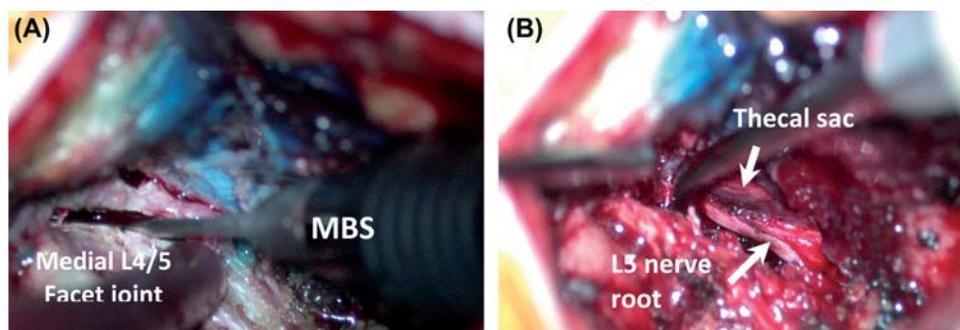


Fig. 2. A & B. Intra-operative images showing the MBS in use to 'unroof' the nerve root.

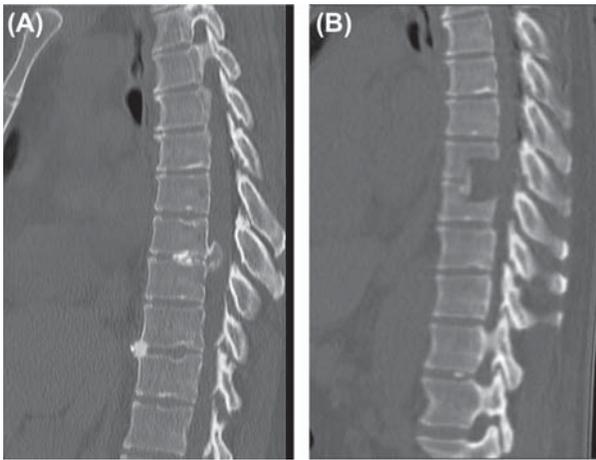


Fig. 3. A. Pre-operative sagittal CT scan showing a giant calcified disc at T8/9. B. Post-operative CT scan: Trench vertebrectomy created with the MBS, preserving the anterior vertebral body.

The MBS was used for the cervical corpectomy, (Fig. 5) which helped reduce the time required and minimised overall blood loss.

Discussion

The incidence of complications in spinal surgery varies, with reports suggesting that anywhere between 10% and 38.6% of patients undergoing a surgical procedure will experience an adverse event.^{8,9} A recent literature review suggested that the overall incidence across spinal surgeries was 16.4%⁸ with thoracolumbar procedures having almost twice the complication rate of cervical procedures: 17.8% versus 8.9%.⁸ The incidence of dural tears across the studies ranged from 1.6%⁸ to 9%,¹⁰ the lower end of that range being comparable with the results from our study (1.6%). Evaluation of a new technique or piece of equipment must be set in this framework. A careful assessment is required to ensure that advances in technique and efficiency are made within the context of patient safety.

The MBS relies on the conversion of electrical impulse to an appropriate ultrasonic frequency to cut bone, whilst minimising trauma to surrounding soft tissue. It is the difference in density and elasticity of the tissue, which allows for this tissue sparing.¹¹

The clinical advantages of these characteristics are a reduced incidence of iatrogenic durotomy and neural injury. Also in the case of a thoracic discectomy, the trench vertebrectomy can be created up to the radicular artery with a reduced risk of arterial damage or traumatic avulsion.¹² This selective tissue cutting is its primary advantage; bone is cut in preference to soft tissue due to its greater rigidity absorbing a large portion of the blade's energy. The physical processes occurring are fragmentation and cavitation.¹³ Whereas soft tissue responds elastically in contact with the blade and therefore moves and vibrates, causing dissemination of energy and the energy actually absorbed at the point of contact is generally not sufficient to cut.¹⁴

Another advantage over rotary drills is the ability to use cotton patties without the nuisance of grabbing. The instrument should ideally be held perpendicular to bone surface. Increasing the rake angle to 20° can lead to a reduction in down-force with a loss in cutting depth. The heat generated by an ultrasonic device on bone has been reported to be no more than that generated by high-speed drills.¹⁵

Producing comparable cases with and without the bone scalpel and estimating the time saved are difficult; however almost two-thirds of cases (74%) were completed in less than 2 h, and surgeons using the MBS did feel that overall it reduced the time spent on operating. Anecdotally, we found the MBS to have a local haemostatic effect and reduced bone bleeding, in keeping with findings from other papers.^{3,16}

The 'feel' of when the inner cortex of bone has been cut is intangible, but will undoubtedly become more consistent as experience is gained with this new equipment. A number of authors have reported an inherent learning curve for piezosurgery^{1,11,17,18} and an associated impact

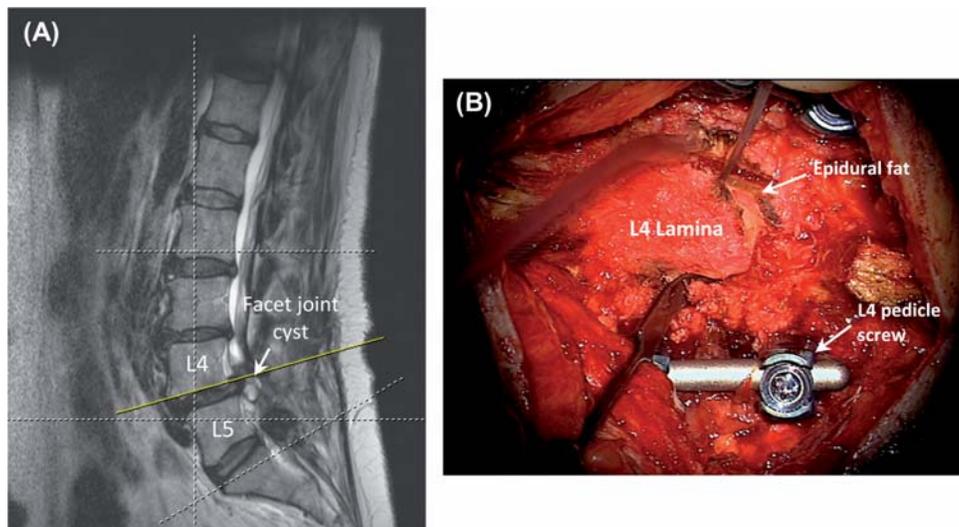


Fig. 4. A. Pre-operative MRI showing a recurrent cyst at L4/5, a Grade 1 degenerative spondylolisthesis and severe central and lateral recess stenosis. B. The MBS is used to achieve a wide laminectomy, with the lamina being detached from the underlying dura and removed en bloc.

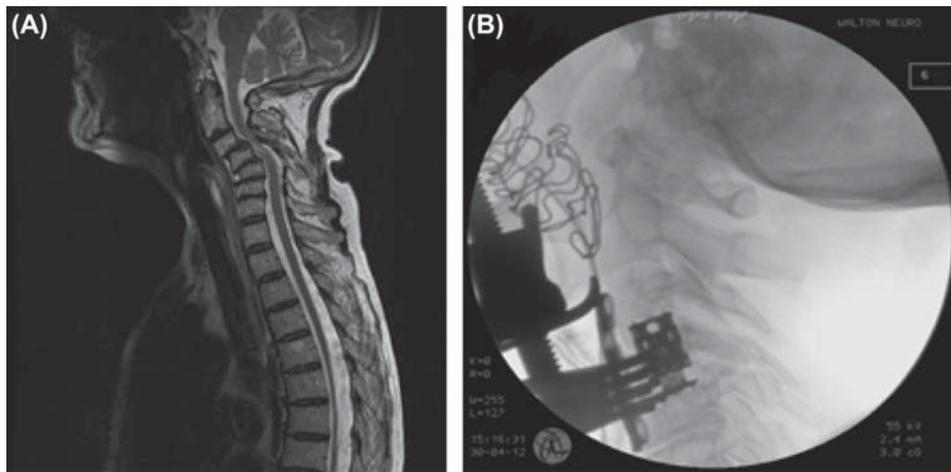


Fig. 5. A. Pre-operative sagittal MRI scan demonstrating multilevel degenerative changes, C3 on C4 anterolisthesis and a resulting kyphotic deformity. B. Intraoperative lateral x-ray showing an expandable C4 cage with anterior plating.

on operating time. Gleizal et al.¹⁶ noted that there was an increase in cutting time compared to traditional drills; however the reduction in soft tissue and neurovascular trauma meant that overall operating time was comparable. Hoigne et al.¹⁹ observed that there was an increase in time for each cut from 10 to 30 s, although with adjusted power settings and opportunity to refine technique this could be reduced.

The main indications for use of the ultrasonic bone cutter in spinal surgery in our experience are as follows^{20–26}:

1. Revision Lumbar decompressions. This could be in the form of a revision microdiscectomy, the bone cutter can aid in creating a bony window and find “virgin” dura avoiding scar tissue. A similar principle is applied in revision laminectomies. The rate of CSF leak is likely to be less here. Further data are required to support this.
2. Laminoplasty. Similar studies found the ultrasonic bone scalpel useful during this procedure with minimal neurovascular and soft tissue damage and no long-term complications.^{2,7}
3. Cervical corpectomy. A bilateral trench is gradually made with removal of intervening bone until the PLL is reached. We found the MBS helpful to expedite this procedure and minimise blood loss.
4. Thoracic trench vertebrectomy. Again may accelerate this step with the ability to preserve radicular vessels and minimise blood loss.
5. Lateral decompression of the lumbar canal – aids in removing bone up to the pedicle without the need of an osteotome, for example exiting root decompression in conjunction with posterolateral instrumented fusion.
6. Although not performed in our unit. En bloc resections may also be aided by this device as demonstrated in other studies.³

Conclusions

The bone scalpel is a useful adjunct in spinal surgery with particular value in revision cases. It possibly carries a low

risk of dural injury (one in this series). Use of the bone cutter appears to be associated with less blood loss. This was most apparent to the senior authors during corpectomies: both cervical and thoracic. In the latter, MBS also protects spinal cord blood supply by preservation of radicular arteries in spite of a wide trench decompression. Further analysis of comparable data is required and individual surgeons’ preferences will vary, but there seems to be an expanding role for the ultrasonic cutter in spinal surgery.

Declaration of interest: The authors report no declarations of interest. The authors alone are responsible for the content and writing of the paper.

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