Piezoelectric Surgery for Dorsal Spine

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BACKGROUND: **Laminoplasty and laminectomy are 2 common surgical procedures used in treating degenerative and neoplastic diseases of the spinal canal. Routinely used instruments, such as the Kerrison rongeur and high-speed drill, can result in potentially serious complications, such as dural injury and thermal and mechanical damage to neurovascular structures. We adopted piezoelectric bone surgery, which permits a selective cut of mineralized tissues, to perform posterior procedures on the thoracic spine, where the relationship between bone and the spinal cord is critical. The aim of this article was to evaluate the use of piezoelectric surgery for performing dorsal spine laminectomy and laminoplasty.**

METHODS: **The Mectron piezosurgery device was developed for cutting bone with microvibrations that are created by the piezoelectric effect. This instrument allows a safe and precise bone cut, and it is characterized by no heat generation, thus avoiding thermal injury to bone and soft tissues. We used this device to perform 8 laminoplasties for tumors of the dorsal spine and 2 laminectomies for thoracic spinal stenosis in 10 patients.**

RESULTS: **There were no procedure-related intraoperative complications, such as dural injury or damage to neural structures.**

CONCLUSIONS: **The piezoelectric device showed excellent results in terms of safety and precise bone cutting properties when performing posterior surgical procedures in the dorsal spine, where thermal injury produced by the conventionally used drill may damage the spinal cord closer to bony elements.**

INTRODUCTION

Laminoplasty and laminectomy are 2 common surgical procedures used in treating degenerative and neoplastic diseases of the spinal canal. The instruments routinely used for osteotomy are the high-speed drill and the Kerrison rongeur. Some risks and potentially serious complications are associated with these instruments, such as dural injuries in patients with a narrow spinal canal and thermal and mechanical damage to neurovascular structures.[1] Piezoelectric bone surgery is a recent innovative technique that permits a selective cut of mineralized tissue while sparing soft tissues.[2,3] This technology has been developed in the last 20 years and has been extensively used in dentistry and maxillofacial surgery. Application has recently spread to many other fields, such as ear, nose, and throat surgery; orthopedic surgery; and cranial and spine surgery.[3,4] In this article, we present our technique to perform posterior spinal procedures with piezoelectric bone surgery. We note the advantages of this technique in the thoracic spine, where the canal is relatively narrow and the relationship between bone and the spinal cord is critical.

MECTRON PIEZOSURGERY DEVICE

The Mectron piezosurgery device (Mectron Medical Technology, Carasco, Italy) cuts bone with microvibrations that are created by the piezoelectric effect with trauma to the surrounding soft tissue minimized. The principle of piezosurgery is ultrasound transduction obtained by piezoelectric ceramic contraction and expansion. The produced vibrations are amplified and transferred onto the device's insert. When applied with slight pressure to the bony tissue, the insert has a mechanical cutting effect exclusively on mineralized tissue, without damaging soft tissue even in case of accidental contact.[4] The system consists of a platform with a piezoelectric device that generates ultrasonic vibrations with variable frequencies of 24–36 kHz and a series of inserts of different forms with a range of linear vibration of 60–200 μm. The insert that we used for spinal procedures, MT1-10, is a small (10 mm long), thin (0.55 mm wide) 5-pointed bone saw,

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Figure 1. Piezosurgery hand piece with the piezoelectric scalpel (MT1-10 insert). (Courtesy of Mectron Medical Technology, Carasco, Italy.)

with a sharp surface, made of medical iron (Figure 1). Moreover, the piezosurgical device is coupled with a peristaltic pump for irrigation using a jet of cold physiologic solution (0.9% saline solution) that discharges from the inserts with 5 different flow rates. Irrigation removes debris from the cutting area, thus providing ideal visualization of the depth of the osteotomy, and ensures the precision of the cut.[3,4]

OPERATIVE TECHNIQUE

The laminae are exposed out to the facet joints. A narrow groove with the shape of the bone opening is performed on the surface of the laminae, "drawing" the shape of a laminotomy. Afterward, the osteotomy is deepened to the dura of the spinal roots, which is not affected by the vibrations of the cutting device. During the procedure, the bone is cut by carefully moving the insert back and forth with little pressure.

When the inner cortex of the bone is actually passed and a sense of loss of resistance is felt, the blade of the instrument is moved into a second position to complete the entire perimeter of the bone window. Thereafter the complex of spinous processes, laminae, and interspinous ligaments is lifted away as a whole with care to avoid angling it in the spinal cord. At the end of a laminoplasty procedure, the laminae are returned as close as possible to their original position and fixed with titanium miniplates and self-taping screws or silk sutures (Figure 2). Conversely, in laminectomy procedures, the bone is not repositioned to allow for adequate spinal decompression.

PATIENTS

We have used the Mectron piezosurgery device in 10 patients; we performed 8 laminotomies with laminoplasty for tumors and 2 laminectomies for thoracic spinal stenosis in the dorsal spine. We have retrospectively reviewed all the surgical records associated with these operations. There were no procedure-related intraoperative complications, such as major bleeding or neural damage owing to lesion of the spinal cord or spinal nerve roots, in any of the surgeries. In addition, there was no evidence of accidental dural tear or postoperative cerebrospinal fluid fistula. The following cases demonstrate our ultrasound-based surgical technique. Informed consent was obtained from patients.

Case 1

Dorsal laminoplasty was performed for spinal meningioma (anterior) (Figure 3). A 53-year-old woman presented with touch hypoesthesia in the dorsal surface of her third and fourth right toes in 2012. The level of sensory deficit was stable until March 2017, when the touch hypoesthesia ascended to the groin level. Whole-spine magnetic resonance imaging showed an intradural extramedullary mass lesion occupying the anterior part of the spinal canal and displacing posteriorly the spine, which appeared extremely thinned in axial sections. To avoid producing thermal or mechanical damage to the spine, which was strongly compressed against the dura, a laminoplasty extending from C7 to D1 was performed with the piezoelectric device. The tumor, which pathologic examination revealed to be a meningioma, was completely removed avoiding neural damage. At discharge, the