10.5005/jp-journals-10039-1106

ORIGINAL ARTICLE

Spinal Decompression using Ultrasonic Bone Scalpel: A Novel Ultrasonic Surgical Device

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ABSTRACT

Introduction: The ultrasonic bone scalpel (UBS) is an ultrasonic device that cuts the bone, but does not harm the surrounding soft tissue and duramater. Such a type of selectivity of bone scalpel, particularly for bone destruction, makes the bone scalpel ideal for spine surgeries where there is the need to remove only bone adjacent to the duramater and neural structures, with the sparing of the duramater. Moreover, dural tear is the most common unintended complication of spinal surgeries nowadays.

Materials and methods: This is a retrospective study of 35 patients operated for spinal decompression – cervical, thoracic, or lumbar – between January 2015 and June 2016 at BJ Medical College, Ahmedabad.

Aim: To analyze the result of the use of UBS in spinal decompression over the conventional method of decompression, such as using the Kerrison Rongeur, high-speed burr drills, and conventional osteotome.

Observation and results: Out of the 35 patients in our study, 21 patients (60%) had cervical, 3 patients (8.6%) had thoracic, and 11 patients (31.4%) had lumbar pathologies. There is significant reduction in duration of surgery and need for blood transfusion. We considered the neck disability index (NDI) and oswestry disability index (ODI) scores to measure the clinical outcomes of using bone scalpel at the end of 1 year. Both the scores were significantly improved. We had one case of dural tear (2.9%) in a patient with lumbar canal stenosis. No neurological worsening in any patients was present.

Conclusion: The UBS is a unique surgical device that reduces heat production and decreases the chances of dural tear, which makes it a suitable instrument for different spinal surgeries in recent days.

Keywords: Dural tear, High-speed drill, Spinal decompression, Ultrasonic bone scalpel.

How to cite this article: Modi JV, Patel KR, Patel Z, Soman SV, Tankshali KV. Spinal Decompression using Ultrasonic Bone Scalpel: A Novel Ultrasonic Surgical Device. J Spinal Surg 2016;3(4):140-143.

Source of support: Nil

Conflict of interest: None

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INTRODUCTION

Dural tear is the most unintended complication of spinal surgeries nowadays. Management of the dural tear requires intraoperative surgical revision with or without fibrin glue or fat-graft placement, or postoperative flat bed rest with drain placement and adequate medication to reduce cerebrospinal fluid (CSF) leakage. Despite these measures, however, complications resulting from dural tears may develop in terms of orthostatic headache, skin necrosis, infection, etc.[1] With the use of the routine method of spinal decompression like Kerrison Rongeur in already stenotic lesions, there is the increased incidence of dural injuries. The use of high-speed drills (HSDs) and diamond burrs may increase heat production and cause damage to the soft tissues. Moreover, the vibration produced by HSDs may cause fatigue to the surgeons and produce discomfort. With the use of ultrasonic bone scalpel (UBS), we can now overcome the hazards of HSDs, diamond burrs, etc.[2,5] The main advantage of the bone scalpel is that it works on a back-and-forth micromotion principle, which reduces the number of rotations and, thereby, reduces the heat production in surrounding soft tissues. Moreover, with the help of the bone scalpel, we can remove the precise part of bone without harming the surrounding soft tissues, thereby reducing the amount of blood loss and total surgery time as well.

MATERIALS AND METHODS

This is a retrospective study of 35 patients operated for spinal decompression – lumbar, cervical, or thoracic – between January 2015 and June 2016 at BJ Medical College, Ahmedabad. Data were collected for all the patients from hospital records. The patients' demographics profile, disease type, duration of surgery, blood loss (measured by weighting gauze piece and measuring drain output during surgery), hospitalization, complications, preoperative oswestry disability index (ODI) and neck disability index (NDI), and 1-year follow-up ODI and NDI scores were recorded (Table 1).

Technical Aspects of UBS

The UBS device includes three parts:

1. Ultrasonic generator
2. Irrigation pipe
3. Cutting blade.

Table 1: Total number of operated patients, gender, operative data, and health survey score

Spinal level	*Number of operations*	*Sex distribution*	*Operation duration (min)*	*Blood loss (mL)*	*Complication(s)*	*Preoperative disability score (%)*	*Postoperative disability score (%)*
Cervical	21	Male – 15 Female – 6	45–60	150–200		60 (NDI)	20
Dorsal	3	Male – 3 Female – 0	120–150	300–500		40 (ODI)	20
Lumbar	11	Male – 9 Female – 2	75–90	200–400	1 (Dural tear)	50 (ODI)	30

NDI: Neck disability index; ODI: Oswestry disability index

The irrigation pipe and cutting blade together along with the handpiece connect to the ultrasonic generator device. The principle of the UBS is back-and-forth micromotion of the cutting blade at around 22,500 times per second. When the ultrasonic cutting blade comes into contact with bone, it does not bend, but transfers the large amount of energy to that point of bone and cuts the bone.[3,6] However, when it comes into contact with soft tissues like duramater or ligamentum flavum, such soft tissues can bend and move away from the tip of the cutting blade. Hence, the ultrasonic blade is not able to transfer high energy to that part of tissue and, thereby, causes no damage to the soft tissues. Angled blade is also available, which is used mainly in lumbar region, where we perform multiple-level decompression (Figs 1 to 3).[4,7,8]

OBSERVATION AND RESULTS

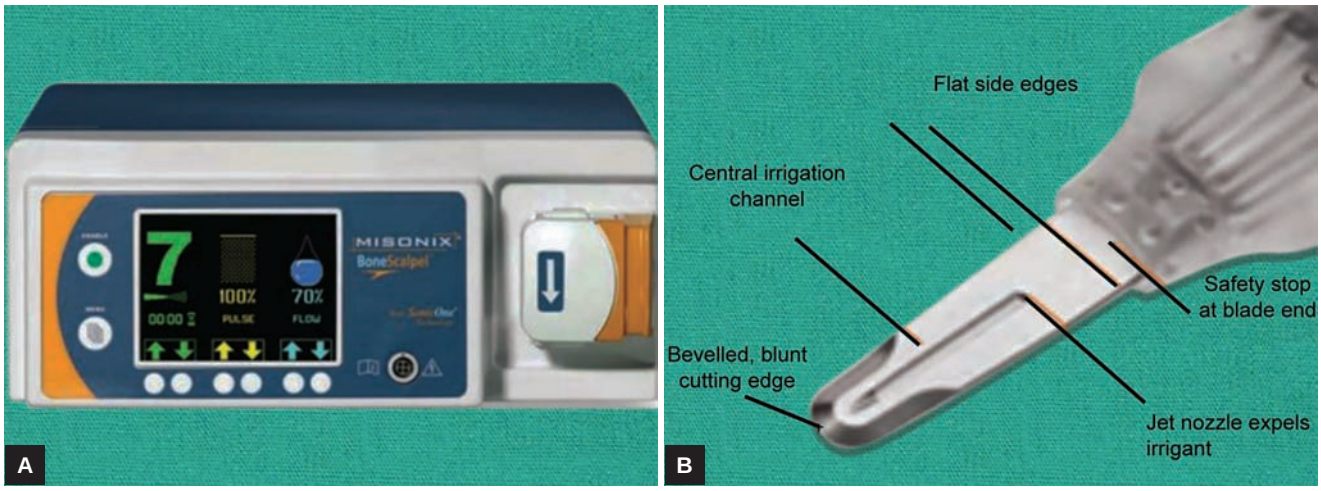
A total of 35 patients underwent surgery for cervical, thoracic, or lumbar spinal pathology mainly through decompression with or without fusion. Mean age of the patients was 62 years (39–72 years). Totally, 27 (77.1%) patients were males and the remaining 8 (22.9%) were females. Out of 35 patients, 21 patients (60%) had cervical, 3 patients (8.6%) had thoracic, and 11 patients (31.4%) had lumbar pathologies.

Patients were operated for various conditions as described in the Table 2.

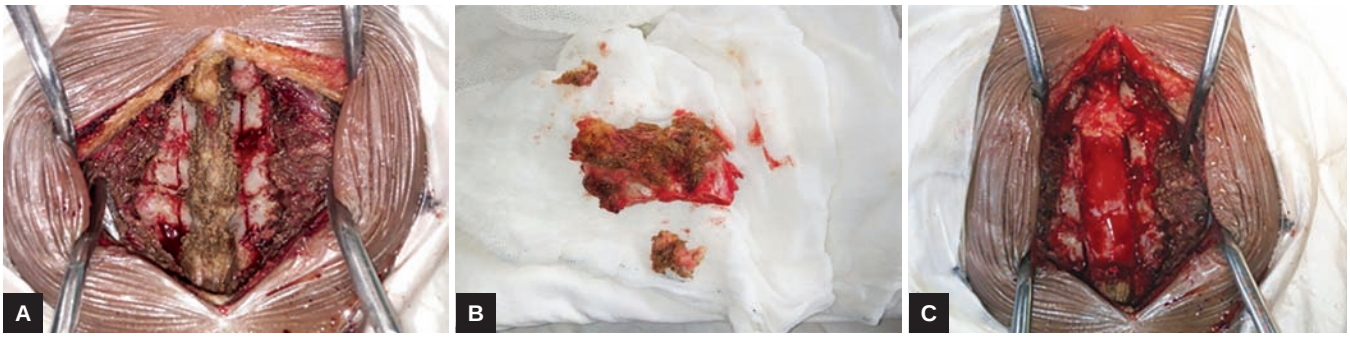
Table 2: Etiologywise distribution of operated patients

Region	*Etiology*
Cervical	Cervical canal stenosis
	Corpectomy
	Calcified disk
	Osteophytes
	Cervical myelopathy
Thoracic	Acquired spinal disorders (fluorosis, tuberculosis)
Lumbar	Lumbar canal stenosis
	Multiple-level pelvic inflammatory disease (PID)
	Recurrent PID
	Cauda Equina syndrome

The duration of the operation is around 90 to 120 minutes in the thoracic, 60 to 75 minutes in the lumbar, and 45 to 60 minutes in the cervical decompression. The mean preoperative ODI score in the lumbar was 40% and in the thoracic was 50%. At follow-up, 1 year after surgery, the ODI score dropped to 20% in lumbar pathology and to 30% in thoracic pathology. The preoperative NDI score in cervical cases was the highest at 60% and dropped to 20% at follow-up after 1 year. The blood loss during surgery is minimal in cervical decompression (250 mL) and maximal in dorsal spinal decompression (500 mL). The hospital stay is quite reduced in comparison to the conventional method of decompression from 4 to 8 days to 2 to 3 days. Complications, such as neurology worsening, infection, and morbidity were not seen in any cases, except one dural tear in lumbar decompression.



Figs 1A and B: Ultrasonic bone scalpel device and its tip view



Figs 2A to C: Intraoperative images during cervical laminectomy done using UBS

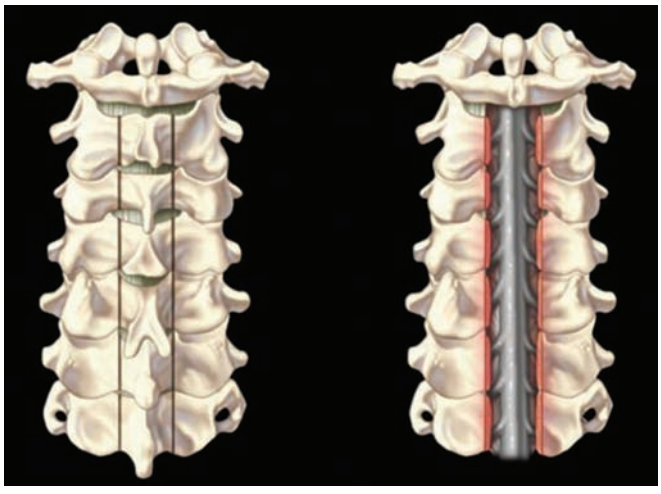


Fig. 3: Approach in cervical laminectomy

DISCUSSION

As mentioned earlier, complications, such as blood loss, dural tear, and thermal trauma are less when UBS is used. Average duration of surgery is reduced as observed in our study. Moreover, with UBS, the bone can be cut with better control and precision. The UBS also has the advantage of its short learning curve compared with burr/drill and reduced fatigue to the surgeon.[3,4]

Bydon et al[2] described 5.7% complication rate of incidental durotomy while performing laminectomy by using UBS, which is similar to the incidence of incidental durotomy found in our study, which is 5%.[2,9]

Oner et al, in their study, found average blood loss during cervical laminectomy to be 380 mL with HSD as compared with 180 mL with UBS. Average blood loss in our study for cervical laminectomy was found to be 250 mL, which supports the finding that UBS causes lower blood loss compared with HSD.[10]

There are very few studies regarding comparison between UBS and other methods of cutting bone. Long-term studies regarding outcomes and side effect(s) need to be considered. The horizon of UBS can also be extended in orthopedic surgeries that require precise bone cutting like hemireplacement arthroplasty. By routine use of UBS, there is reduced blood loss and one can harvest intact bone bloc, which can be used as bone graft, thereby reducing the need for bone substitutes like bone morphogenic protein and bone stimulators. Due to lower blood loss, the rate of blood transfusion is also reduced. The UBS, being costly, has a questionable affordability in an individual setup, but is cost-effective when used in government hospitals.

It is specifically beneficial to our society in tertiary health centers, where there is a huge patient load. Moreover, there is higher incidence of fluorosis, ossified yellow ligament, multiple-level pelvic inflammatory disease, and corpectomy. Due to various advantages of bone scalpel, such as less duration, decreased blood loss, less fatigue of surgeon, higher number of patients can be operated, we can reduce patients' load and maximum number of patients can benefit from it. Most importantly, the reduced risk of CSF leak and neurological injury provide significant economic benefits, such as reduced use of expensive bony substitutes and number of blood transfusions; additionally, it reduces the duration of hospitalization, rates of readmission, and other complications.

CONCLUSION

Bone scalpel is an effective ultrasonic device that becomes an essential component in spine surgeries where there is a risk of dural injury. It is superior to power drills and diamond burrs for bone cutting in various spinal surgeries. The judicious use of this device requires a tactile feel for bone when it is penetrated. The limitation is its cost in individual setups, but once the tactile feel and *en bloc* bone elevation techniques have been mastered, spinal decompression can be performed with more safety and efficiency.

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