The Use of an Ultrasonic Bone Curette in the Surgery of Jaw Tumors Involving the Inferior Alveolar Nerve

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BACKGROUND

Preservation of lip sensation is crucial in ablative surgery of mandibular tumors. When tumor control does not necessitate sacrifice of the inferior alveolar nerve (IAN), as in some cases of benign tumors of the lower jaw, attempts may be made to spare the nerve. The authors present and discuss their experience with an ultrasonic device in the treatment of benign tumors of the jaw in correspondence of the IAN.

MATERIALS AND METHODS

Five patients with tumoral lesions involving the IAN underwent surgery with an ultrasonic surgical device (Sonopet Omni Surgical System; Stryker, Kalamazoo, MI).

RESULTS

Fine, delicate movements allowed the surgeon to remove bone without damage to surrounding tissue. Three of 5 patients did not present intraoperative or postoperative complications that could be attributed to the Sonopet. Two cases were partial failures. In 1 case, postoperative dysesthesia was encountered, and in the other case, intraoperative transection of the nerve occurred.

CONCLUSION

The Sonopet ultrasonic bone curette proved to be highly useful in surgical procedures close to the IAN because it does not produce heat or cause mechanical injury to the neurovascular bundle. Application of this instrument may provide improved ability to preserve sensibility of the chin and lower lip in patients affected by lesions in proximity to the IAN.

Ultrasonic vibrations have been used for cutting in neurosurgery for decades.[1, 2, 3, 4, 5, 6 and 7] However, it is only in recent years that experimental devices have been used routinely for standard clinical applications in many fields of oral and maxillofacial surgery.[8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47 and 48]

Preservation of lip sensibility is important in oral function after ablative surgery. The lower lip is innervated by the inferior alveolar nerve (IAN). The IAN provides unilateral sensation to the teeth and, through the mental nerve, to the anterior labial mucosa and the skin from the commissure to the mental protuberance.

In the dental literature, it is generally claimed that the use of ultrasonic devices decreases the risk of damaging surrounding soft tissues and critical structures (nerves, vessels, and mucosa), particularly during osteotomies. In their works on IAN transposition, Meltzger (in sheep)[49] and Bovi (in humans)[24 and 26] observed that Piezoelectric devices, as opposed to conventional burs, have a lower rate of damage to soft tissue, specifically to neurovascular tissue.

In cases in which tumor control does not imply sacrifice of the IAN, as in some benign tumors of the lower jaw, attempts may be made to spare the nerve.
This article presents and discusses experience with ultrasonic devices in surgery of benign tumors involving the IAN, as well as a case of an extremely rare neoplasm of the IAN.

MATERIALS AND METHODS

The design of this study was exempt from the approval of the local institutional review board. The Sonopet Omni Ultrasonic Surgical System (Stryker, Kalamazoo, MI) was used. The action of this bone curette consists of a ultrasonic frequency vibrating surgical tip produced by a Piezoelectric element exposed to alternate current.
The inclusion criterion for this prospective study was the presence of tumor lesions that were in contact with IAN.
Five patients (2 men, 3 women) were included in the study. The average age of the study population was 42.2 years (range 36-50 years, SD 5.58 years, median 42 years). Table 1 provides the characteristics of the study population.

Table 1.

Study Population

Patient	Age	Sex	Symptoms	Diagnosis	Approach
1	42	F	Pain	Schwannoma of the IAN	Intraoral
2	50	M	Swelling	Odontogenicmyxoma	Intraoral
3	38	F	Asymptomatic	Ossifying fibroma	Intraoral
4	36	F	Swelling	Odontogenicmyxoma	Submandibular
5	45	M	Swelling	Ossifying fibroma	Intraoral

Abbreviation: IAN, inferior alveolar nerve.

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RESULTS

Ultrasonic bone curettage occurred after gross high-speed drilling. A high-speed drill was preferred for resecting large amounts of bone because it required less time to complete gross bone ablation. Sonopet was used when the lesion or the bone to be drilled was close to the IAN.
Fine and delicate movements allowed the surgeon to remove bone without damaging surrounding tissues. Bone was easily resected with minimal pressure from the tip of the handpiece against the bone surface using simple scratching, as with a curette. No significant heat generation was observed. No dehiscences or infections occurred in any patient.
In this study population, 3 of 5 patients (Patients 2, 4, and 5) did not present any intraoperative or postoperative complications that could be attributed to the Sonopet. Two of 5 cases (Patients 1 and 3) were partial failures. In 1 case, postoperative dysesthesia was encounters; in the other case, intraoperative transection of the IAN occurred.

DISCUSSION

Ultrasonic surgery was developed in response to the need for greater precision and safety in bone surgery, compared with manual and motorized instruments. Ultrasonic surgical devices generally operate in a high-power, low-frequency range of 20 to 60 kHz for biological tissue cutting, ablation or fragmentation, and removal. A frequency from 25 to 29 kHz is used because micromovements that are created at this frequency (amplitude ranging from 60 to 210 μm) cut only mineralized tissue. Neurovascular tissue and other soft tissues are cut at frequencies higher than 50 kHz. These devices have gained widespread acceptance in dentistry, neuro-, orthopedic, ophthalmic, plastic, and maxillofacial surgeries.

In the dental literature, it is generally claimed that the use of ultrasonic devices decreases the risk of damaging surrounding critical structures (nerves, vessels, mucosa), particularly when performing osteotomies (Table 2). The Piezosurgery system (Mectron, Carasco, Italy) was the first ultrasonic lancet on the market. It is made of a generator of intermediate frequencies and a pump that enables irrigation. Experiences in the English dental literature are based exclusively on this kind of instrument. The parameters that are directly controlled by the operator, apart from manually applied pressure, are the pulse frequency (when available), the rate of delivery of coolant fluid, and applied power, which in some instruments is limited to 3 to 16 W and in others has a maximum of as much as 90 W. In most instruments, power is controlled by selecting the type of bone to be cut or the procedure to be performed. The peak-to-peak amplitude of tip oscillations, typically in the range of 30 to 200 m perpendicular to the shaft of the working piece (some instruments also or exclusively oscillate along the shaft) ensures precise microabrasive incision.

Table 2.

Literature on Ultrasonic Devices

Applications	Authors	Year of Publication
Sinus lift	Torrella et al[8]	1998
	Vercellotti et al[9]	2001
	Eggers et al[10]	2004
	Stübinger et al[11]	2005
	Vercellotti et al[12]	2006
	Schlee et al[13]	2006
	Wallace et al[14]	2007
	Stübinger et al[15]	2008
	Barone et al[16]	2008
	Blus et al[17]	2008
	Stübinger et al[18]	2009
	Toscano et al[19]	2010
	Vercellotti[20]	2000
	Blus and Szmukler-Moncler[21]	2006
Alveolarridgeexpansion	Schlee et al[13]	2006
	Enislidis et al[22]	2006
	Stübinger et al[15]	2008
Exposure of impactedcanines	Grenga and Bovi[23]	2004
Lateralization of the IAN	Bovi[24]	2005

Applications	Authors	Year of Publication
	Stübinger et al[11]	2005
	Leclercq et al[25]	2008
	Stübinger et al[15]	2008
	Bovi et al[26]	2010
Removal of hard tissue close to the IAN	Stübinger et al[11]	2005
Autologous bone graftharvesting	Stübinger et al[11]	2005
	Stübinger et al[27]	2006
	Schlee et al[13]	2006
	Happe[28]	2007
	Sohn et al[29]	2007
	Gellrich et al[30]	2007
	Leclercq et al[25]	2008
	Stübinger et al[15]	2008
Periodontalsurgery	Vercellotti et al[12]	2006
Transposition of the IAN	Sakkas et al[31]	2008
Alveolardistractionosteogenesis	González-García et al[32]	2007
	Lee et al[33]	2007
	González-García et al[34]	2008
Removal of osseointegratedimplants	Sivolella et al[35]	2007
	Leclercq et al[25]	2008
Maxillofacialsurgery	Ueki et al[36]	2004
	Robiony et al[37]	2004
	Geha et al[38]	2006
	Kotrikova et al[39]	2006
	Nordera et al[40]	2007
	Ueki et al[41]	2007
	Gonzalez-Lagunas and Mareque[42]	2007
	Robiony et al[43]	2007
	Robiony et al[44]	2007
	Landes et al[45]	2008
	Landes et al[46]	2008
	Degerliyurt et al[47]	2009
Muñoz-Guerra et al[48]	2009	

Abbreviation: IAN, inferior alveolar nerve.

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Sonopet ultrasonic bone curettes have been used successfully in ear, nose, and throat surgery,[50 and 51]spine surgery, and neurosurgery.[1, 2, 3, 4, 5 and 6]In maxillofacial surgery, the use of

Sonopet has been described for performing Le Fort I–type osteotomies[36]and for establishing a guiding notch before completing sagittal split osteotomy.[41]

This ultrasonic surgical device comprises a power supply unit, foot switch, and handpiece. The handpiece weighs 110 g, is 140 mm in length from tip to angled section, and is 20 mm in thickness. The longitudinal vibration amplitude varies from 120 to 365 µm, and the ultrasonic frequency is 25 kHz. Longitudinal-torsional amplitude is also available for more effective bone cutting. The adjustable cooling irrigation fluid (20°C) emerges through the sheath near the tip of the handpiece. A suction device is attached that draws the tissue into or against the device for more effective ablation.

When tumor management does not require sacrifice of IAN, as in some cases of benign lower jaw tumors, attempts may be made to spare the nerve. This article presents and discusses experience with SONOPET in benign tumor surgery of the jaw in proximity to the IAN, as well as an extremely rare neoplasm of the IAN. The authors adopted this device because there was consistent literature on the treatment of intra- and extracranial neoplasms using the instrument.[7, 51, 52 and 53]

Bone removal may carry some risk to neural tissue. Indeed, any inadvertent contact of the rapidly rotating drill with the IAN may cause permanent damage to the nerve.[2]Moreover, the use of a high-speed drill increases the temperature in the operative field and may affect the nerve, even in the absence of any mechanical compression.[3 and 4]

Drilling in proximity of the IAN implies heat generation, problems in visualization, and, therefore, risk of neural damage.

These limitations appear to be minimized with the Sonopet. As Nakase et al[1]and Hadeishi et al[5] have proposed, it was thought that the combined use of a drill followed by Sonopet could make bone removal easier, safer, and faster than using either alone. Furthermore, in various series, complications attributable to heat injury were not observed. This is probably due to automatic irrigation of cool saline solution.[6]The ultrasonic bone curette resects bone through ultrasonic oscillation not rotation moments, and nerve tissue actually absorbs the oscillation.[54]Thus, the risks of injuring the IAN should be prevented with this device.

From what has been described in neurosurgery literature, the handpiece seems to allow fine control. This ultrasonic bone curette produces a minimal amount of bone dust compared with a typical drill. Furthermore, bone scraping is smooth and gradual, and it can be limited to the contact area.[51]

In our series, 3 of 5 cases had no intraoperative or postoperative complications that could be attributed to the Sonopet. In these patients, the anatomy of the IAN canal was fully preserved within the tumor mass. The intervention was highly comparable to an IAN transposition, and, in accord with Nakase et al's claim, this device may reduce the surgical complication rate.[1] This was especially true for tumors of nervous origin.

Two of 5 cases were partial failures. In 1 case, we encountered postoperative dysesthesia, and intraoperative transection of the nerve occurred in the other case. Three hypotheses may explain the damage related to this specific treatment of jaw tumors. First, these 2 tumors were heterogeneous and had a nonlinear, inelastic, anisotropic character that varied throughout the mass. Second, the amount of collagen within these neoplasms is variable and unpredictable, and it is responsible for tensile strength of any tissue. Finally, apart from reporting that ultrasonic-curetted bone surfaces were less smooth than those drilled by a rotary diamond bur, Metzger et al[49]provided evidence that epineurium lesions still occurred, but the nerve itself was not affected. In the case in which the nerve was damaged, we observed a true lack of an IAN bony canal and a histologically proved calcification of the epinevrium. The mechanical action on a harder-than-normal epinevrium might have indirectly caused damage to the underlying nerve.

Setting of the device apparatus seems difficult in cases like these because one must choose a definite work frequency, even though the texture of the mass is mixed and ultrasounds are absorbed unevenly. For these reasons, the results of jaw tumor removal close to the IAN are not fully predictable.

Ultrasonic bone curettes generally show other disadvantages. They require more time and do not seem suitable for resections of large amounts of bone.[1 and 2] Moreover, in our experience, the angle of the Sonopet tip has to be as close to perpendicular as possible because the use of the working side of the tip may tear neural tissue. Therefore, the Sonopet does not automatically protect neural tissue, especially in a transoral approach.[2] Finally, the cost of this device is significant, and thus its use might be limited to larger centers, perhaps shared among different departments (eg, maxillofacial surgery; neurosurgery; and ear, nose, and throat).

The Sonopet ultrasonic bone curette was revealed to be highly useful in surgical procedures adjacent to the IAN. It avoids heat production and mechanical injury to the neurovascular bundle. Application of this instrument might provide improved ability to preserve sensibility of the chin and lower lip in patients affected by lesions in proximity to the IAN. The Sonopet could represent a valid alternative to standard surgical drills for IAN surgery. However, further studies are needed to confirm these results and to extend the possible uses of this system to other surgical procedures.

REFERENCES

1. H. Nakase, R. Matsuda, Y. Shin, *et al.*
The use of ultrasonic bone curettes in spinal surgery
Acta Neurochir (Wien), 148 (2006), p. 207

2. H.S. Chang, M. Joko, J.S. Song, *et al.*
Ultrasonic bone curettage for optic canal unroofing and anterior clinoidectomy
J Neurosurg, 104 (2006), p. 621

3. K. Kim, T. Isu, R. Matsumoto, *et al.*
Surgical pitfalls of an ultrasonic bone curette (Sonopet) in spinal surgery
Neurosurgery, 59 (suppl 4) (2006), pp. ONS390–ONS393 discussion ONS393

4. T. Abe, K. Satoh, A. Wada
Optic nerve decompression for orbitofrontal fibrous dysplasia: Recent development of surgical technique and equipment
Skull Base, 16 (2006), p. 145

5. H. Hadeishi, A. Suzuki, N. Yasui, *et al.*
Anterior clinoidectomy and opening of the internal auditory canal using an ultrasonic bone curette
Neurosurgery, 52 (2003), p. 867
K. Ito, S. Ishizaka, T. Sasaki, *et al.*

6. Safe and minimally invasive laminoplasticlaminotomy using an ultrasonic bone curette for spinal surgery: Technical note
Surg Neurol, 72 (2009), p. 470

7. H. Nakagawa, S.D. Kim, J. Mizuno, *et al.*
Technical advantages of an ultrasonic bone curette in spinal surgery
J Neurosurg Spine, 2 (2005), p. 431

8. F. Torrella, J. Pitarch, G. Cabanes, *et al.*
Ultrasonic ostectomy for the surgical approach of the maxillary sinus: A technical note
Int J Oral Maxillofac Impants, 13 (1998), p. 697

9. T. Vercellotti, S. de Paoli, M. Nevins
The Piezoelectric bony window osteotomy and sinus membrane elevation: Introduction of a new technique for simplification of the sinus augmentation procedure
Periodontics J, Dent R, 21 (2001), pp. 561–567

10.G. Eggers, J. Klein, J. Blank, *et al.*
Piezosurgery: An ultrasound device for cutting bone and its use and limitations in maxillofacial surgery
Br J Oral Maxillofac Surg, 42 (2004), p. 451

11.S. Stübinger, J. Kuttenberger, A. Filippi, *et al.*
Intraoral Piezosurgery: Preliminary results of a new technique
J Oral Maxillofac Surg, 63 (2005), p. 1283

12.T. Vercellotti, A.S. Pollack
A new bone surgery device: Sinus grafting and periodontal surgery
Compend Contin Educ Dent, 27 (2006), p. 319

13.M. Schlee, M. Steigmann, E. Bratu, *et al.*
Piezosurgery: Basics and possibilities
Implant Dent, 15 (2006), p. 334
S.S. Wallace, Z. Mazor, S.J. Froum, *et al.*

14.Schneiderian membrane perforation rate during sinus elevation using Piezosurgery: Clinical results of 100 consecutive cases
Int J Periodontics Restorative Dent, 27 (2007), p. 413

15.S. Stübinger, C. Landes, O. Seitz, *et al.*
Ultrasonic bone cutting in oral surgery: A review of 60 cases
UltraschallMed, 29 (2008), p. 66

16.A. Barone, S. Santini, S. Marconcini, *et al.*
Osteotomy and membrane elevation during the maxillary sinus augmentation procedure: A comparative study: Piezoelectric device vs. conventional rotative instruments
Clin Oral Implants Res, 19 (2008), p. 511

17.C. Blus, S. Szmukler-Moncler, M. Salama, *et al.*
Sinus bone grafting procedures using ultrasonic bone surgery: 5-year experience
Int J Periodontics Restorative Dent, 28 (2008), p. 221

18.S. Stübinger, B. Saldamli, O. Seitz, *et al.*
Palatal versus vestibular Piezoelectric window osteotomy for maxillary sinus elevation: A comparative clinical study of two surgical techniques
Oral Surg Oral Med Oral Pathol Oral RadiolEndod, 107 (2009), p. 648

19.N.J. Toscano, D. Holtzclaw, P.S. Rosen
The effect of Piezoelectric use on open sinus lift perforation: A retrospective evaluation of 56 consecutively treated cases from private practices
J Periodontol, 81 (2010), p. 167

20.T. Vercellotti
Piezoelectric surgery in implantology: A case report—a new Piezoelectric ridge expansion technique
Int J Periodontics Restorative Dent, 20 (2000), p. 358

21.C. Blus, S. Szmukler-Moncler
Split-crest and immediate implant placement with ultra-sonic bone surgery: A 3-year life-table analysis with 230 treated sites
Clin Oral Implants Res, 17 (2006), p. 700

22.G. Enislidis, G. Wittwer, R. Ewers

Preliminary report on a staged ridge splitting technique for implant placement in the mandible: A technical note
Int J Oral Maxillofac Implants, 21 (2006), p. 445

23.V. Grenga, M. Bovi
Piezoelectric surgery for exposure of palatally impacted canines
J Clin Orthod, 38 (2004), p. 446

24.M. Bovi
Mobilization of the inferior alveolar nerve with simultaneous implant insertion: A new technique: Case report
Int J Periodontics Restorative Dent, 25 (2005), p. 375

25.P. Leclercq, C. Zenati, D.M. Dohan
Ultrasonic bone cut: Part 2: State-of-the-art specific clinical applications
J Oral Maxillofac Surg, 66 (2008), p. 183

26.M. Bovi, A. Manni, L. Mavriqi, *et al.*
The use of Piezosurgery to mobilize the mandibular alveolar nerve followed immediately by implant insertion: A case series evaluating neurosensory disturbance
Int J Periodontics Restorative Dent, 30 (2010), p. 73

27.S. Stübinger, A. Robertson, K.S. Zimmerer, *et al.*
Piezoelectric harvesting of an autogenous bone graft from the zygomaticomaxillary region: Case report
Int J Periodontics Restorative Dent, 26 (2006), p. 453

28.A. Happe
Use of a Piezoelectric surgical device to harvest bone grafts from the mandibular ramus: Report of 40 cases
Int J Periodontics Restorative Dent, 27 (2007), p. 241

29.D.S. Sohn, M.R. Ahn, W.H. Lee, *et al.*
Piezoelectric osteotomy for intraoral harvesting of bone blocks
Int J Periodontics Restorative Dent, 27 (2007), p. 127

30.N.C. Gellrich, U. Held, R. Schoen, *et al.*
Alveolar zygomatic buttress: A new donor site for limited preimplant augmentation procedures
J Oral Maxillofac Surg, 65 (2007), p. 275

31.N. Sakkas, J.E. Otten, R. Gutwald, *et al.*
Transposition of the mental nerve by Piezosurgery followed by postoperative neurosensory control: A case report
Br J Oral Maxillofac Surg, 46 (2008), p. 270

32.A. González-García, M. Diniz-Freitas, M. Somoza-Martín, *et al.*
Piezoelectric bone surgery applied in alveolar distraction osteogenesis: A technical note
Int J Oral Maxillofac Implants, 22 (2007), p. 1012

33.H.J. Lee, M.R. Ahn, D.S. Sohn
Piezoelectric distraction osteogenesis in the atrophic maxillary anterior area: A case report
Implant Dent, 16 (2007), p. 227

34.A. González-García, S.-M.M. Diniz-Freitas, A. García-García
Piezoelectric and conventional osteotomy in alveolar distraction osteogenesis in a series of 17 patients
Int J Oral Maxillofac Implants, 23 (2008), p. 891

35.S. Sivolella, M. Berengo, M. Fiorot, *et al.*
Retrieval of blade implants with Piezosurgery: Two clinical cases
Minerva Stomatol, 56 (2007), p. 53

36.K. Ueki, K. Nakagawa, K. Marukawa, *et al.*
Le Fort I osteotomy using an ultrasonic bone curette to fracture the pterygoid plates
J Craniomaxillofac Surg, 32 (2004), p. 381

37.M. Robiony, F. Polini, F. Costa, *et al.*
Piezoelectronic bone cutting in multipiece maxillary osteotomies
J Oral Maxillofac Surg, 62 (2004), p. 759

38.H.J. Geha, A.M. Gleizal, N.J. Nimeskern, *et al.*
Sensitivity of the inferior lip and chin following mandibular bilateral sagittal split osteotomy using Piezosurgery
Plast Reconstr Surg, 118 (2006), p. 1598

39.B. Kotrikova, R. Wirtz, R. Krempien, *et al.*
Piezosurgery—a new safe technique in cranial osteoplasty?
Int J Oral Maxillofac Surg, 35 (2006), p. 461

40.P. Nordera, S. Spanio di Spilimbergo, A. Stenico, *et al.*
The cutting-edge technique for safe osteotomies in craniofacial surgery: The Piezosurgery bone scalpel
Plast Reconstr Surg, 120 (2007), p. 1989

41.K. Ueki, K. Nakagawa, K. Marukawa, *et al.*
Use of the Sonopet ultrasonic curettage device in intraoral vertical ramus osteotomy
Int J Oral Maxillofac Surg, 36 (2007), p. 745

42.J. Gonzalez-Lagunas, J. Mareque
Calvarial bone harvesting with Piezoelectric device
J Craniofac Surg, 18 (2007), p. 1395

43.M. Robiony, F. Polini, F. Costa, *et al.*
Ultrasonic bone cutting for surgically assisted rapid maxillary expansion (SARME) under local anaesthesia
Int J Oral Maxillofac Surg, 36 (2007), p. 267

44. M. Robiony, F. Polini, F. Costa, C. Toro, M. Politi
Ultrasound Piezoelectric vibrations to perform osteotomies in rhinoplasty
J Oral Maxillofac Surg, 65 (2007), p. 1035

45. C.A. Landes, S. Stübinger, J. Rieger, *et al.*
Critical evaluation of Piezoelectric osteotomy in orthognathic surgery: Operative technique, blood loss, time requirement, nerve and vessel integrity
J Oral Maxillofac Surg, 66 (2008), p. 657

46. C.A. Landes, S. Stübinger, A. Ballon, *et al.*
Piezoosteotomy in orthognathic surgery versus conventional saw and chisel osteotomy
Oral Maxillofac Surg, 12 (2008), p. 139

47. K. Degerliyurt, V. Akar, S. Denizci, *et al.*
Bone lid technique with Piezosurgery to preserve inferior alveolar nerve
Oral Surg Oral Med Oral Pathol Oral Radiol Endod, 108 (2009), p. e1

48. M.F. Muñoz-Guerra, L. Naval-Gías, A. Capote-Moreno
Le Fort I osteotomy, bilateral sinus lift, and inlay bone-grafting for reconstruction in the severely atrophic maxilla: A new vision of the sandwich technique, using bone scrapers and Piezosurgery
J Oral Maxillofac Surg, 67 (2009), p. 613

49. M.C. Metzger, K.H. Bormann, R. Schoen, *et al.*
Inferior alveolar nerve transposition—an in vitro comparison between Piezosurgery and conventional bur use
J Oral Implantol, 32 (2006), p. 19

50. R.N. Samy, K. Krishnamoorthy, M.L. Pensak
Use of a novel ultrasonic surgical system for decompression of the facial nerve
Laryngoscope, 117 (2007), p. 872

51. F. Pagella, G. Giourgos, E. Matti, *et al.*
Removal of a fronto-ethmoidalosteoma using the Sonopet Omni Ultrasonic Bone Curette: First impressions
Laryngoscope, 118 (2008), p. 307

52. P. Cappabianca, L.M. Cavallo, I. Esposito, *et al.*
Bone removal with a new ultrasonic bone curette during endoscopic endonasal approach to the sellar-suprasellar area: Technical note
Neurosurgery, 66 (2010), p. E118

53. T. Inoue, K. Ikezaki, Y. Sato
Ultrasonic surgical system (SONOPET) for microsurgical removal of brain tumors
Neurol Res, 22 (2000), p. 490

54. B.K. Howard, S.J. Beran, J.M. Kenkel, *et al.*
The effects of ultrasonic energy on peripheral nerves: Implications for ultrasound-assisted liposuction
Plast Reconstr Surg, 103 (1999), p. 984