Piezosurgery for osteotomies in orbital surgery: Our experience and review of the literature

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A R T I C L E   I N F O

Article history:
Received 6 September 2012
Received in revised form 7 November 2012
Accepted 8 November 2012
Available online 17 November 2012

Keywords:
Craniotomy
Orbital surgery
Skull base surgery
Piezosurgery
Ultrasound scalpel

A B S T R A C T

INTRODUCTION: Piezoelectric bone surgery, simply known as Piezosurgery®, is a new promising technique for bone cutting based on ultrasonic microvibrations that allows to perform precise and thin osteotomies with soft tissue sparing.

PRESENTATION OF CASE: A 45-years-old woman presenting with progressive left ocular pain, diplopia on the lateral left gaze, and visible exophthalmos was admitted to our department. CT scan and MRI images documented a left supero-lateral orbital lesion. A left lateral orbitotomy using the piezoelectric scalpel was performed. The tumour (lacrimal gland lymphoma) was completely removed with no injuries to the orbital structures and with a perfect realignment of the bone stumps.

DISCUSSION: High powered pneumatic osteotome are commonly used to perform craniotomies. Large bone cutting groove and high temperatures developing at the contact site could produce an uneasy bone healing. The use of a piezoelectric scalpel allows to realize precise and thin osteotomies, facilitating craniotomy’s borders ossification and avoiding injuries to non-osseous structures.

CONCLUSION: Widely used in Oral and Maxillofacial Surgery, Piezosurgery® can also be useful in neurosurgical approaches in order to obtain a faster bone flap re-ossification, a better aesthetic result, and a lower risks of dural layer and soft tissue damage.

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1. Introduction

In the past, one of the leading problems in neurosurgery was how to perform a rapid and effective skull openings avoiding or minimizing the risks of injuries to the underlying structures.¹,² This problem found a partial solution with the diffusion of the oscillating saws and high powered pneumatic trephines that are extremely efficient in terms of speed and skull penetration but, at the same time, enormously destructive on the craniotomy’s borders and potentially harmful on non-osseous structures like the dural layer or other soft tissues. These limitations become particularly evident in cases where craniotomy must be performed in areas of minimal bone width and abundant soft tissue representation, like the orbit. Piezosurgery®, is a new promising technique for precise, thin bone cutting, based on ultrasonic microvibrations allowing selective cutting of the mineralized bone while preserving the soft tissues, with potentially no injuries to the underlying critical structures.²-⁵ This is the main characteristic of the Piezosurgery®, but other potential advantages include optimal visibility in the surgical field, decreased blood loss, regular and thin bone cutting facilitating the bone flap healing, good aesthetic results as well as increased comfort for the patient, and a lower risk of seroma formation.³,⁴ All this potential advantages, theoretically renders Piezosurgery®, an extremely useful tools in skull base surgery, especially around the orbit and anterior skull base, where craniotomies have to be performed in visible regions and thus require good aesthetic results.

2. Case presentation

In a 2-year time period, 8 patients were treated at our Department by the use of Piezosurgery® (Mectron Medical Technology, Carasco, Italy). There were 5 males and 3 females with age ranging from 21 to 70 years (mean age: 49 years). Surgery was performed for the removal of 5 fronto-orbital meningiomas and 3 tumours located in the superolateral region of the orbit. All meningiomas were approached by an eyebrow supraorbital key-hole approach, orbital tumors were removed by a lateral orbitotomy. Final fixation of the removed bone was always performed by titanium low profile miniplates and screws. Piezosurgery® technical specifications are as follow. Ultrasound are generated by ceramic transducers crossed by electrical current, with frequencies from 24.7 to 29.5 kHz, determining differences in cutting strength. The applied
power can be modulated between 2.8 and 16 W and is programmed in accordance to the density of the bone. The microvibrations that are created in the piezoelectric hand piece cause the inserts to vibrate linearly between 60 and 210 μm. This vibration provokes the phenomenon called cavitation, which makes possible the selective cutting of mineralized bone, preserving from inadvertent damage the surrounding soft tissues (i.e. dura mater, brain, and orbital contents).4

We present here one exemplificative case of an orbital tumor with intraorbital hypertension. This was a 45-years-old woman, with an history of progressive ocular pain, visible exophthalmos and subsequent onset of diplopia on the lateral left gaze. The neuroimaging studies (CT scan and MRI images) documented the exophthalmos provoked by an orbital lesion localized in the supero-lateral region (Fig. 1). The patient was operated on using the piezoelectric scalpel to perform a left lateral orbitotomy. The osteotomy was uneventful, even in case of unintentional contact by the piezoelectric scalpel with the lesion or the orbital content. The thin bone line cutting allowed a perfect realignment of the bone stumps (Fig. 2). Tumour removal was complete and blood loss was minimal. The patient did not present any complications, discomfort and she was discharged at home 3 days later (Fig. 3). At 3-months’ follow-up visit, she presented an excellent postoperative wound healing with good aesthetical results (Fig. 4).

3. Discussion

The piezoelectric device is a new bony scalpel using microvibrations at ultrasonic frequency as selective bone cutting with soft tissue preservation (nerve, vessel, dura mater, etc.). In our experience, Piezosurgery® provided an excellent maneuverability without harming effects on the adjacent structures, even in case of unintentional contact with the dura mater, capsule of Tenon or supraorbital nerve. Piezosurgery® made possible to perform precise osteotomy lines (Fig. 2) with a thinner cutting groove and a minor area of bone damage than those created by high powered pneumatic trephines or oscillating saws (Fig. 5).4,6,7 These properties guarantee a faster and better healing process of the bone flap by favouring the osteocytes viability from the craniotomy’s borders.4,8 The safety of Piezosurgery® on soft tissues was experimentally verified on rats by Pavlíková et al. who performed minicranietomy using conventional drilling on one side and Piezosurgery® on the other one. The results of MRI and histological evaluation showed a significantly increased depth and width of brain microlesion in the region of conventional drilling compared to the region where Piezosurgery® was used. They concluded that Piezosurgery® is a safe method to make osteotomies in close relation to soft tissues, including an extremely injury-sensitive tissue such as brain.9 The safety of Piezosurgery® was clinically verified as well. Salami et al.

Fig. 1. Forty-five years old woman affected by a left lacrimal gland B-cell lymphoma. Preoperative CT scan (a, b) and MRI images (c) showed an occupying-space mass located in the supero-lateral orbital region.

Fig. 2. Intraoperative images showing the osteotomies performed by piezoelectric bone scalpel (a, b) and the final bone reconstruction with low profile miniplates and screws (c).

Fig. 3. Post-operative scout view (a) and axial (b, c) CT scan demonstrating the optimal bone re-alignment.
Fig. 4. Intraoperative incision (a) and its long-term cosmetic result (b).

Fig. 5. Intraoperative image of a supraorbital craniotomy performed by a traditional high speed drill and with a piezoelectric bone scalpel. It is evident the different bone groove width, gap and regularity created by these instruments.

stated that the piezoelectric device is proved to be effective in sclerotic and pneumatic mastoid, with an excellent maneuverability and without side effects on the adjacent structures of the middle and inner ear (lateral sinus, facial nerve, and/or dura mater). Their experience highlights the safety of the piezoelectric device in terms of cutting precision and healing process. Another interesting issue has been stated by the same authors. It is a well know concept that in every field of surgery, the second operation is always much more difficult than the first one. This is basically due to scar formation and lost of the normal anatomical landmarks. The authors proved Piezosurgery® to be very efficient and safe during revision surgery where “blind” osteotomy are at higher risk of soft tissue damage.10,11 Pereira et al. had the same experience, concluding that Piezosurgery® transforms critical operations in simple and fully executable procedures with a reduced risk of soft and neurovascular tissues damage.8 The reliability of Piezosurgery® in dealing with delicate structures like nerves was also confirmed by Bovi et al. during the inferior alveolar nerve mobilization for reconstruction of the atrophic posterior mandible. They stated that this device enables the oral surgeon to avoid nerve overstretching by creating a small and precise bone window.12 Cho et al. compared ultrasonic cutting with high speed drill in patients with thyroid eye disease and intraorbital hypertension where the orbital structures were compressed against the bone hence more prone to be damaged during osteotomy. Beside true damage of soft tissues, primary outcome measures included visual acuity, proptosis, lagophthalmos, eyelid retraction, and exposure keratopathy. They stated that ultrasonic bone removal is a safer and effective alternative to high-speed drill in performing lateral orbital decompression for thyroid eye disease.13

In our experience the major limitations of Piezosurgery are the slowness of the existing instrumentation and the limited variety of tips for the handpiece when compared to conventional high speed mechanical tools. This might represent a significant limitation, especially when working in narrow corridors or in complex surgical procedures where a long operative time is yet expected. In our case series, the operative time for performing osteotomy was on average 20% longer than with traditional mechanical instruments. However, considering the time spending to preserve the orbit and dura from damage, the time used to control bleeding from craniotomy borders, and the time needed to address an eventual dural or soft tissues damage, the overall surgical procedure duration was not significantly longer. Sortino et al. also reported that the piezoelectric osteotomy technique produced a reduced amount of facial swelling and trismus at 24 h from surgery, but it required a longer surgery time when compared with the rotatory osteotomy technique.14

This is why we propose Piezosurgery only in selected cases, (as for example orbital osteotomies and minimally invasive anterior skull base approaches), not in the routine use and/or for large craniotomies.
4. Conclusion

Piezosurgery® due to its soft tissue-sparing effects and atraumatic bone cutting is a promising technical modality for bone surgery in which a selective action upon the mineralized tissues is needed to reduce osteotomy-related complications. Our experience with the use of Piezosurgery® seems encouraging and we feel that its application to skull base procedures, where minimally invasiveness is now more and more searched and limited working bone windows are needed, can be one of the most promising fields of application.

Conflict of interest statement

None.

Funding

None.

Ethical approval

Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

Author contributions

All authors have contributed significantly and all authors are in agreement with the content of the manuscript. Maurizio Iacoangeli, Piergiorgio Neri, Paolo Balercia, and Massimo Scerrati performed operation at least one of these 8 cases; Ettore Lupi, Alessandro Di Rienzo, Niccolò Nocchi, and Lorenzo Alvaro wrote the paper, collected the data and literature, and interviewed the patients.

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