

Piezoelectric Bone Surgery Applied in Alveolar Distraction Osteogenesis: A Technical Note

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Piezoelectric bone surgery is based on ultrasonic vibration of a device functioning as an osteotome. This device allows precise cuts to be made in bone structures without provoking lesions of adjacent soft tissues and at the same time offering excellent visibility within the surgical field. The use of this technique in alveolar distraction osteogenesis is described. Piezoelectric surgery appears to make the cutting of the transport segment easier and safer. INT J ORAL MAXILLOFAC IMPLANTS 2007;22:1012-1016

Key words: bone surgery, distraction osteogenesis, piezoelectric surgery

Dentists are often faced with inadequate maxillary bone height or width in patients requiring implant-supported rehabilitations. In cases of inadequate height (ie, an inadequate apicocoronal dimension), only short implants can be placed, leading to unfavorable crown-to-implant length ratio.¹ In these situations it is common to attempt to increase the available bone height. One widely used technique is alveolar distraction osteogenesis, which is based on the gradual separation of a free bone segment (the transport segment, fully vascularized via the periosteum) from the basal bone in such a way that a distraction callus and subsequently mature bone forms between the transport segment and the basal bone.² In cases of inadequate height, vertical alveolar distraction osteogenesis thus enables a more favorable crown-to-implant length ratio³ (Figs 1 and 2).

In order to ensure adequate vascularization of the transport segment in alveolar distraction, it is necessary to maintain the integrity of the lingual periosteum. In this connection, ultrasonic techniques are of

great interest. These techniques have been applied in diverse fields of medicine⁴⁻⁷ with good results. The applications of ultrasound in odontology include root scraping, endodontal procedures, and preparation of the retrograde cavity in apicectomies.⁸ However, one of the most common applications is piezoelectric bone surgery, which enables very precise incisions to be made with minimal damage to adjacent structures.

Although piezoelectric osteotomy in alveolar bone was first described in the 1970s and 1980s,^{9,10} this technique was not widely adopted until after the description of its use for alveolar ridge expansion by Vercellotti et al¹¹ in 2000. Subsequently, diverse uses have been reported in oral surgery, including sinus membrane elevation,^{12,13} removal of impacted canines,¹⁴ multipiece maxillary osteotomy,¹⁵ removal of tissues close to the inferior dental nerve,¹⁶ and obtainment of autologous bone grafts.¹⁷

The following is a description of the application of piezoelectric bone-cutting techniques in alveolar distraction osteogenesis.

PATIENT SELECTION AND PROCEDURES

All patients included in the study were patients who had consulted the Oral Surgery and Medicine Unit at the University of Santiago de Compostela for placement of implant-supported dentures and in whom prior evaluation had indicated a need for vertical alveolar distraction.

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Fig 1 Left side prior to distraction. Note the excessive crown-implant ratio that would result if ridge augmentation were not carried out.

Fig 2 (right) Before alveolar distraction.



Fig 3 (left) The Piezosurgery System. The system includes a handpiece with a fitted insert tip, a dynamometric wrench for inserting the tip, and a cooling system with a bag of irrigation solution.

Fig 4 (above) (a) Osteotomy insert tips kit. (b) Detail of the OT6 insert tip habitually used by the authors for osteotomy in alveolar distraction.

Piezosurgery Apparatus

The Piezosurgery System (Mectron Medical Technology, Carasco, Genova, Italy; Fig 3) comprises a central unit with control panel and control pedal, the piezoelectric handpiece with functional vibration frequency ranging from 25 to 30 kHz as required by the operator, and an associated cooling system, which allows irrigation with up to 60 mL/min of sterile cooling solution. The handpiece is fitted with one of a series of vibrating heads ("insert tips"), with different shapes and surface characteristics depending on the type of surgery (Fig 4). Power can be adjusted between 5 and 16 W, and the side-to-side vibration amplitude of the insert tip ranges correspondingly from 60 to 210 μm .

Surgical Procedure

All patients underwent vertical alveolar distraction by the method of Chin,¹⁸ with minor modifications

per García et al.³ The surgery was carried under local anesthesia. A crestal incision was made along the length of the alveolar process, and a mucoperiosteal flap was raised without severing the connection between the lingual periosteum and the transport segment. The transport segment was cut in an inverted trapezoidal shape (Fig 5). The transport segment was divergent in the crestal direction, so as not to interfere with its mobility during distraction. It was created with sufficient mesiodistal length to allow subsequent placement of the implants. The osteotomy was commenced by marking the vertices of the trapezoid with a Lindemann burr in a Frios straight handpiece (Friadent, Mannheim, Germany). The incisions were then completed with a Piezosurgery System OT6 insert tip (Fig 4b). For bone cutting, the authors have found the "boosted" mode to be most effective, with application of the insert tip perpendicular to the bone (Fig 5) under maximum



Fig 5 Intraoperative photograph showing application of the insert tip perpendicular to the cut surface. Note the shape of the transport segment and the good visibility in the surgical field.

Fig 6 (right) At the start of the consolidation period.



Fig 7 Intraoral photograph of the left side after rehabilitation showing the implant-supported fixed denture.

Fig 8 (right) One month after placement of the definitive denture.



irrigation. It is necessary to find a balance between high velocity and low pressure, since excessive pressure on the bone prevents the vibration. In this respect, a useful guide is the sound made by the handpiece. There should be no variation in the sound as ultrasonic root scraping occurs. Also, it is important to make frequent short pauses during the osteotomy to prevent the insert tip from impacting the bone or from overheating or breaking.

To complete the osteotomy it is important to check the lingual finish by moving the transport segment over its full range of movement, with the aim of confirming that the segment does not show any points of excessive friction. Any final adjustments required can be made with a chisel.

Subsequently, the distractor is placed (screw, base plate, and transport plate) in line with the procedure described by Chin.¹⁸ Once in place, the transport segment is raised to a height of 5 mm without disconnecting the mucoperiosteal flap to ensure adequate

mobility during the distraction period and to confirm that its freedom of movement and vector of distraction are adequate. The segment is then returned to its original position.

Distraction is started 7 days later at a rate of 0.5 mm every 12 hours until the required height has been reached. At the end of the distraction period the distraction area is examined radiologically (Fig 6). After 12 weeks, the distractor is removed, and the implants are placed. After another 6 weeks, the implants are ready for loading³ (Figs 7 and 8).

DISCUSSION

Piezoelectric bone cutting is based on controlled ultrasonic vibration of the instrument head, known as the insert tip. The cut obtained is micrometric, due to the very small vibration amplitude of the insert tip (60 to 210 μm side-to-side, 20 to 60 μm vertically).¹⁹ The cut

is selective, since the vibration frequency used only cuts bone tissue, not soft tissue.¹⁹ The surgical field remains relatively free of blood, because of the irrigation and ultrasonic effects on the irrigation solution (known as the “cavitation effect”).

As a result of these characteristics, piezoelectric techniques allow very precise cuts. The integrity of adjacent soft tissues (notably the periosteum and vascular/nerve bundles) and very good visibility in the surgical field can be maintained.^{15,20} The design of the insert tips and full control over vibration rate contributes greatly to the precision of this technique^{15,20} and reduces the risk of complications related to damage to adjacent soft tissues, including nerves and blood vessels. The aforementioned cavitation effect is due to the creation of depressions in the irrigation solution, which give rise to bubbles of saturated vapor that in turn form smaller bubbles, so that the irrigation solution forms an aerosol with improved capacity to remove detritus and keep the surgical field clean.

Alveolar distraction osteogenesis is a relatively new technique that requires some surgical skill and is associated with frequent minor complications.²¹ The osteotomy is the most difficult part of the procedure, since it is necessary to preserve the integrity of the lingual periosteum, which will maintain the vascularization of the transport segment.² Vertical alveolar distraction, which is aimed at increasing alveolar ridge height prior to endosseous implant placement, is typically performed in partially or entirely edentulous patients, and thus often close to functionally important structures such as the inferior dental nerve or schneiderian membrane. This proximity to such structures complicates the procedure. In such cases it is very important for the cut to be precise, and piezosurgery is ideal for this purpose, in that the vibrating insert tip cuts only bone, not soft tissues.

Nevertheless, there is some risk of tissue lesion if the technique is not used correctly (eg, if excessive pressure is applied with the insert tip, if the tip is allowed to overheat or break). This latter risk is lower with piezoelectric instruments than with conventional instruments, and the likelihood of causing marginal osteonecrosis is lower.²² To the authors’ knowledge, there have been no studies of possible adverse effects on bone after piezoelectric osteotomy, such as thrombogenesis or impaired bone blood flow. Experiments in animals^{23,24} have indicated that ultrasonic frequencies above 20 kHz can induce intravascular clots. This possibility, particularly in the mandible, where the vascularization is already poor, may have negative consequences.

Piezoelectric bone surgery appears well suited for osteotomy in alveolar distraction osteogenesis. It

allows precision cutting with low risk of damage to nearby soft tissues (including the inferior dental nerve and lingual periosteum) and offers excellent visibility of the surgical field. Promising results have been obtained with ultrasonic bone cutting techniques in several previous studies in the oral context,^{16,22,23} but further comparative studies of its efficacy and its complications are required before this technique can be adopted as a routine clinical practice.

REFERENCES

1. Friberg B, Jemt T, Lekholm U. Early failures in 4641 consecutively placed Brånemark dental implants: A study from stage 1 surgery to the connection of completed prostheses. *Int J Oral Maxillofac Implants* 1991;6:142–146.
2. Arosen J. Principles of Distraction Osteogenesis. Distraction of the Craniofacial Skeleton. New York: Springer-Verlag, 1999:51–64.
3. García A, Somoza M, Gándara P, Saulacic N, Gándara J. Alveolar distraction prior to placement of dental implants in the posterior mandible. *Br J Oral Maxillofac Surg* 2003;41:376–379.
4. Shelley ED, Shelley WB. Piezosurgery: A conservative approach to encapsulated skin lesions. *Cutis* 1986;38:123–126.
5. Sherman JA, Davies HT. Ultracision: The harmonic scalpel and its possible uses in maxillofacial surgery. *Br J Oral Maxillofac Surg* 2000;38:530–532.
6. Lee SJ, Park KH. Ultrasonic energy in endoscopic surgery. *Yonsei Med J* 1999;40:545–549.
7. Vaezy S, Martin R, Kaczkowski P, et al. Use of high-intensity focused ultrasound to control bleeding. *J Vasc Surg* 1999;29:533–542.
8. Gay EC. Application of ultrasonics in periapical surgery. *Eur J Odontol* 1996;8:207–214.
9. Horton JE, Tarpley TM Jr, Wood LD. The healing of surgical defects in alveolar bone produced with ultrasonic instrumentation, chisel, and rotary bur. *Oral Surg Oral Med Oral Pathol* 1975;39:536–546.
10. Horton JE, Tarpley TM Jr, Jacoway JR. Clinical applications of ultrasonic instrumentation in the surgical removal of bone. *Oral Surg Oral Med Oral Pathol* 1981;51:236–242.
11. Vercellotti T. Piezoelectric surgery in implantology: A case report—A new piezoelectric ridge expansion technique. *Int J Periodontics Restorative Dent* 2000;20:358–365.
12. Vercellotti T, de Paoli S, Nevins M. The piezoelectric bony window osteotomy and sinus membrane elevation: Introduction of a new technique for simplification of the sinus augmentation procedure. *J Periodontics Restorative Dent* 2001; 21:561–567.
13. Torrella F, Pitarch J, Cabanes G, Anitua E. Ultrasonic ostectomy for the surgical approach of the maxillary sinus: A technical note. *Int J Oral Maxillofac Implants* 1998;13:697–700.
14. Grenga V, Bovi M. Piezoelectric surgery for exposure of palatally impacted canines. *J Clin Orthod* 2004;38:446–448.
15. Robiony M, Polini F, Costa F, Vercellotti T, Politi M. Piezoelectric bone cutting in multipiece maxillary osteotomies. *J Oral Maxillofac Surg* 2004;62:759–761.
16. Stübinger S, Kuttenberger J, Filippi A, Sader R, Zeilhofer HF. Intraoral piezosurgery: Preliminary results of a new technique. *J Oral Maxillofac Surg* 2005;63:1283–1287.

17. Chiriac G, Herten M, Schwarz F, Rothamel D, Becker J. Autogenous bone chips: Influence of a new piezoelectric device (piezosurgery) on chip morphology, cell viability and differentiation. *J Clin Periodontol* 2005;32:994–999.
18. Chin M. Distraction osteogenesis for dental implants. *Atlas Oral Maxillofac Clin North Am* 1999;7:41–63.
19. Vercellotti T. Technological characteristics and clinical indications of piezoelectric bone surgery. *Minerva Stomatol* 2004;53:207–214.
20. Eggers G, Klein J, Blank J, Hassfeld S. Piezosurgery: An ultrasound device for cutting bone and its use and limitations in maxillofacial surgery. *Br J Oral Maxillofac Surg* 2004;42:451–453.
21. García-García A, Somoza-Martín M, Gándara-Vila P, López-Maceiras J. Minor complications arising in alveolar distraction osteogenesis. *J Oral Maxillofac Surg* 2002;60:496–501.
22. Vercellotti T, Nevins ML, Kim DM, et al. Osseous response following resective therapy with piezosurgery. *Int J Periodontics Restorative Dent* 2005;25:543–549.
23. Walmsley AD, Laird WR, Williams AR. Intra-vascular thrombosis associated with dental ultrasound. *J Oral Pathol* 1987;16:256–259.
24. Williams AR. Intravascular mural thrombi produced by acoustic microstreaming. *Ultrasound Med Biol* 1977;3:191–203.