ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)
IJDSIR : Dental Publication Service
Available Online at: www.ijdsir.com
Volume – 6, Issue – 2, April - 2023, Page No. : 115 – 122

Piezosurgery: A boon for modern implantology

[1]Dr Kiran Deepak Koulgikar, Department of Periodontics and Implantology, Hke's S. Nijalingappa Institute of Dental Science and Research, Kalaburagi, Karnataka, India, 585101

[2]Dr Shrikar R Desai, Department of Periodontics and Implantology, Hke's S. Nijalingappa Institute of Dental Science and Research, Kalaburagi, Karnataka, India, 585101

[3]Dr Jayashree A Mudda, Department of Periodontics and Implantology, Hke's S. Nijalingappa Institute of Dental Science and Research, Kalaburagi, Karnataka, India, 585101

[4]Dr Veena A Patil, Department of Periodontics and Implantology, Hke's S. Nijalingappa Institute of Dental Science and Research, Kalaburagi, Karnataka, India, 585101

[5]Dr Priya Toshniwal, Department of Periodontics and Implantology, Hke's S. Nijalingappa Institute of Dental Science and Research, Kalaburagi, Karnataka, India, 585101

[6]Dr Bhagyashree Patil, Department of Periodontics and Implantology, Hke's S. Nijalingappa Institute of Dental Science and Research, Kalaburagi, Karnataka, India, 585101

Corresponding Author: Dr Kiran Deepak Koulgikar, Department of Periodontics and Implantology, Hke's S. Nijalingappa Institute of Dental Science and Research, Kalaburagi, Karnataka, India, 585101

Citation of this Article: Dr Kiran Deepak Koulgikar, Dr Shrikar R Desai, Dr Jayashree A Mudda, Dr Veena A Patil, Dr Priya Toshniwal, Dr Bhagyashree Patil, "Piezosurgery: A boon for modern implantology", IJDSIR - April - 2023, Volume – 6, Issue - 2, P. No. 115 – 122.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Piezosurgery (piezoelectric bone surgery) is a promising, precise, bone-cutting system that is based on ultrasonic micro-vibrations and spares soft tissue. The cuts produced by piezosurgery are micrometric and selective and most of the damage is limited to the adjacent tissues with minimum trauma. Piezoelectric osteotomy devices are based on the modulation of ultrasonic vibration of an active tip called insert and are characterized by three essential points: 1) precise and clean cutting, 2) selective bone-cutting, and 3) surgical field relatively free of blood. Piezoelectric implantology is a new technique that involves ultrasonic implant site preparation (uisp) that reforms primary stability through the differential implant site preparation of cancellous and cortical bone. This technique is characterized by a rapid and intense tissue healing response referred to as ultra-osseointegration, which represents a new standard in osseointegrated implantology. The piezosurgical implantology in comparison to the conventional technique affords precise and selective cutting with enhanced intraoperative control which accounts for minimal trauma to the tissues. This review article aims to focus on the clinical applications of piezosurgery in implantology and demarcate their advantages and disadvantages over conventional surgical systems and their biological aspects. The piezoelectric device has wide use in implantology which serves abundant applications such as implant surgery, ridge augmentation, sinus floor elevation, bone graft harvesting, lateralization of inferior alveolar nerve, and ridge expansion. Concerning current and future minimally invasive and innovative surgical concepts, piezoelectric surgery offers a wide range of new possibilities to perform customized osteotomies for bone reconstruction and placement of dental implants with more predictability, less post-operative pain, and increased patient compliance.

Keywords: Piezosurgery, Dental Implants, Osteotomy, Osseointegration, Ridge Augmentation

Introduction

Over the last few decades, there has been rapid development in various dental surgical techniques, evolving a world of painless dentistry. Traditionally, hand instruments and various rotary instruments were used for osseous surgery. This led to heat production, which necessitates external copious irrigation while performing the surgeries. In addition to heat, a considerable amount of pressure was also exerted in osseous surgeries, with a limitation in the case of fractured or brittle bones.[1] to overcome these limitations, a new paradigm shift in osseous surgeries, termed piezosurgery, has occurred over time. Piezoelectric bone surgery was introduced in dentistry by the oral surgeon tomaso vercellotti in 1988.[2]piezosurgery (piezoelectric bone surgery) is a promising, precise, bone-cutting system that is based on ultrasonic micro-vibrations and spares soft tissue. The cuts produced by piezosurgery are micrometric and selective and most of the damage is limited to the adjacent tissues with minimum trauma.[3,4] the distinguishable features of the piezoelectric device are ultrasonic micro-vibrations with an average frequency of 25–29 khz, an oscillation (amplitude) of 60–210 µm, and power up to 50 w, which allows selective cutting only in mineralized structures without damaging soft tissue.[5–8] piezoelectric osteotomy devices are based on the modulation of ultrasonic vibration of an active tip called insert and are characterized by three essential points: 1) precise and clean cutting, 2) selective bone-cutting, and 3) surgical field relatively free of blood[2] Piezoelectric implantology is a new technique that involves ultrasonic implant site preparation (uisp) that reforms primary stability through the differential implant site preparation of cancellous and cortical bone. This technique is characterized by a rapid and intense tissue healing response referred to as ultra-osseointegration, which represents a new standard in Osseo integrated implantology. The piezo surgical implantology in comparison to the conventional technique affords precise and selective cutting with enhanced intraoperative control which accounts for minimal trauma to the tissues.[9] this review article aims to focus on the clinical applications of piezosurgery in implantology and demarcate their advantages and disadvantages over conventional surgical systems and their biological aspects.

Biological aspects of piezosurgery in bone tissues

The bone tissue is sensitive to thermal injury and the temperature threshold survival of this tissue during osteotomy is established at 47^0 c for 1 min which is documented by zadehet al[10] and sclar et al[11]. The osteotomy procedure involving the repeated use of burs, drills, and saws reduces the cutting power and results in excessive trauma, followed by an increase in frictional heat. Chiriac et al[12] in their study proved that bone chips harvested by piezoelectric surgery, and with a conventional rotating drill, contained vital cells that have the capacity to differentiate into osteoblasts in vitro. Von see et al[13] showed that the cell count contained more osteoblast-like cells in the harvested samples when a piezoelectric device was used. Vercellotti et al[14] made a comparison based on the response of bone after osteotomy and osteoplasty with a carbide drill, a diamond drill, and piezosurgery after 14, 28, and 56 days. They concluded that: (1) the surgical sites which were treated with carbide and diamond drills resulted in bone loss in 14 days, contrary to piezosurgery, where there was an increase in bone tissue. (2) there was an increase in the bone level with the regeneration of cementum and periodontal ligament after 28 days in the 3 systems used. (3) the piezosurgery system increased bone mass, whereas carbide and diamond drills resulted in a loss of bone tissue at 56 days post-surgery. This study highlighted the greatest capacity of bone regeneration and efficacy with the use of piezosurgery. In another histomorphological study, porous titanium implants were embedded into the minipigs' tibia. The sample of bone tissues showed elevated levels of morphogenetic protein 4 (bmp-4), transforming growth factor 2 (tgf-2), tumor necrosis factor, interleukin-1, and interleukin-10. The analysis showed that neo-osteogenesis was consistent and more active in bone samples of sites for implants prepared with piezosurgery, with an early increase in bmp-4 and tgf-2 and a few proinflammatory cytokines in the bone around the implants. Based on these results, the piezoelectric bone surgery technique showed to be more capable than the conventional system. There was an early proliferation of bone morphogenetic proteins and better inflammatory process control, and bone remodeling was evident in 56 days.[15]

Applications of piezosurgery in implantology

The piezoelectric device has wide use in implantology which serves abundant applications such as implant surgery, ridge augmentation, sinus floor elevation, bone graft harvesting, lateralization of inferior alveolar nerve, and ridge expansion.

Preparation of the implant site

In healthy bony conditions, piezosurgery can be advocated for the preparation of the implant site.[16] special drills are available which allow for the drilling of a precise implant hole, which in turn will reduce the thermal and mechanical damage to the bone. In a prospective study conducted by da silva neto et al[17] with 30 implant sites that received dental implants using either conventional drilling or piezoelectric tips, the resonance-frequency value was significantly high in the piezosurgery group compared to the conventional drilling. This indicates that the implant stability quotient was significantly greater for implants placed with piezosurgery compared to the conventional technique. In 2007, preti et al[18] conducted a study to assess the neo-osteogenesis and inflammatory reaction after implant-site preparation in two groups, comparing piezosurgery and conventional drills. They discovered that during the early phase (7–14 days), the piezoelectric implant site showed an increased amount of osteoblasts and more newly formed bone when compared to conventional drilling. In their study, bmp-4, tgf-β_2, tnfα, il-1β, and il-10 were investigated in detail. During this early period, the piezoelectric group showed an increase in bmp-4, tgf-β_2, and il-10, while il-1β and tnfα were not.[18] in conclusion, the piezoelectric device stimulated peri-implant osteogenesis and a reduction of proinflammatory cytokines.

Sinus floor elevation

The sinus-floor elevation is often the most suitable solution to prepare a sufficient donor site for implant insertion, in edentulous patients with insufficient bone volume and reduced height of the alveolar crest. Al-dajani et al[19] found that the risk for the incidence of sinusitis or infection is doubled with the perforation of the schneiderian membrane. Therefore, it is of great importance that perforation of the schneiderian membrane should be avoided. Seoane et al[20] showed that the use of the piezoelectric device reduces the frequency of membrane perforation among surgeons with limited experience. Vercellotti et al[21] published a surgical protocol using piezoelectric surgery showing a clear reduction (5%) of membrane perforation. In comparison, the prevalence with rotary instrumentation varies between 5% and 56%.[22,23] advantage of using piezosurgery is the thin cut that is produced by it. Sohn et al[24] showed that the replacement of the bony lateral window into the former defect is possible with ease when using the piezoelectric device. Furthermore, another striking advantage of piezoelectric surgery is its use during the same surgical session for harvesting bone. Stacchi et al[25] published a scraping–pulling fashion, in which the gained bone chips can then be used for augmentation, or they can be mixed with various non-autologous materials and placed in the sinus.

Bone graft harvesting

Majewski et al[26] in their study have shown that with the use of piezosurgery, it was possible to harvest an accurate shape of the bone block for a ridge defect, in turn allowing for stabilization of the block into the recipient size more precisely. Piezosurgery also allowed to delicately shape and contour the cortical part of the graft serving as an element supporting the shape of the reconstructed alveolar process. Bone graft particles with a size of 500 µm are ideal for bone regeneration, maintaining the osteogenic, osteoinductive, and osteoconductive ability. Piezosurgery is the most suitable device to collect bone particles of ideal size with low heat generation, which in turn minimizes the possibility of thermal necrosis.[27] in these surgical procedures where bone graft harvesting is necessary, large surgical access is often required to collect the ideal bone quantity and to protect the surrounding soft tissues and vital anatomical structures. In such conditions where there is a small access area, the piezosurgery tip of low amplitude is more precise and safer, thereby providing a significant reduction of intraoperative bleeding. The technique's sensitivity also is highly advantageous in delicate surgeries.[28]

Edentulous alveolar ridge splitting

The edentulous ridge-splitting technique can be applied in case of insufficient width of the alveolar ridge. Even if the inferior alveolar nerve is accidentally touched, the procedure is very safe when using the piezoelectric device as bland tips are available. As no graft is needed in case of edentulous ridge expansion, the donor site morbidity can be avoided which is an added advantage.[29] amato et al[30] revealed that the maxilla allows an effective and fast osteotomy with atraumatic ridge expansion. A study by majewski et al[26] in the evaluation of ultrasonic bone surgery or piezosurgery, in cases of split-crest procedures with immediate implant placement, displayed an overall success rate of 97.2%, with no risk of thermonecrosis, minimum risk of soft tissue alteration, and satisfactory bone cutting efficiency. The ridge splitting of the mandible can raise complications due to the inferior alveolar nerve, particularly if a significant amount of bone is lost. Another risk factor is the fracturing of the bone segments in the cortical mandible. Edentulous ridge splitting is possible with conventional instruments, but the piezoelectric device showed a different dimension. Bone separation using the piezoelectric device is even possible in difficult bony situations, due to the exact and well-defined cutting abilities. [31,32]

Lateralization of the inferior alveolar nerve

The localization of the inferior alveolar nerve can vary distinctively in the edentulous mandible. Gowgiel et al[33] in their cadaveric study found out that, “the distance between the lateral border of the neurovascular bundle and the external surface of the outer buccal cortical plate was usually half a centimeter in the molar and premolar regions”. It is of utmost importance to perform osteotomies with a device that reduces the risk of nerve damage, especially in cases with limited access and view. The characteristic shape of the piezoelectric tip, surgical control, and the cavitation effect of the device supports the operator in interventions involving the inferior alveolar nerve.[34] this accounts for the removal of deeply impacted wisdom teeth, which are often located close to the inferior alveolar nerve, as well as for the lateralization of the inferior alveolar nerve. This procedure is an alternative to the augmentation technique if implants are planned in an edentulous jaw.[35] for this, free and clear access to the nerve is desirable. This can be achieved by performing cuts with the piezoelectric device so that the cortical lateral bone lid is replaceable over the neurovascular bundle. This procedure protects the nerve structure after nerve retraction and transposition.[36] in situations where nerve contact cannot be avoided, salami et al[37] reported that the negative side effects are much higher if a rotating instrument comes into contact with the nerve. As the piezoelectric device produces less noise, the major advantage of using this device is that patients experience less stress and fear. The micro-vibrations produced by the piezoelectric device in comparison to a conventional bur appear to be less stressful for the patient.[37] the only known disadvantage of it is the slightly longer operating time, but this can be accepted considering all the advantages.

Conclusion

In conclusion, the clinical rationale that uplifts the growth of piezoelectric implantology depends on lowering the surgical risk involved and achieving a more effective clinical healing response. The main objective is to improve the immediate loading technique through the use of micro-vibrations that, combined with the cavitation effect and sonic overmodulation, activate the process of tissue ultra-osseointegration.[18]concerning current and future minimally invasive and innovative surgical concepts, piezoelectric surgery offers a wide range of new possibilities to perform customized osteotomies for bone reconstruction and placement of dental implants.

References

1. Thomas, Mathai; Akula, Uttam[1]; Ealla, Kranti K. R.[2,]; Gajjada, Nirosha[2]. Piezosurgery: A Boon for Modern Periodontics. Journal of International Society of Preventive and Community Dentistry 7(1):p 1-7, Jan–Feb 2017. | DOI: 10.4103/2231-0762.200709
2. Vercellotti T. La chirurgiaosseapiezoelettrica. Il dentistamoderno2003;5:21-5
3. Covani U, Barone A. Piezosurgical treatment of unicystic ameloblastoma. J Periodontol. 2007 Jul;78(7):1342-7. Doi: 10.1902/jop.2007.060417. PMID: 17608590
4. Gleizal A, Bera JC, Lavandier B, Beziat JL. Piezoelectric osteotomy: a new technique for bone

surgery-advantages in craniofacial surgery. Childs Nerv Syst. 2007 May;23(5):509-13. Doi: 10.1007/s00381-006-0250-0. Epub 2007 Mar 14. PMID: 17356890.

5. 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 Oct;42(5):451-3. Doi: 10.1016/j.bjoms.2004.04.006. PMID: 15336773.
6. Schaller BJ, Gruber R, Merten HA, Kruschat T, Schliephake H, Buchfelder M, Ludwig HC. Piezoelectric bone surgery: a revolutionary technique for minimally invasive surgery in cranial base and spinal surgery? Technical note. Neurosurgery. 2005 Oct;57(4 Suppl):E410; discussion E410.doi:10.1227/01.neu.0000176700.77461.c9. PMID: 16234663.
7. Vercellotti T. Technological characteristics and clinical indications of piezoelectric bone surgery. Minerva Stomatol. 2004 May;53(5):207-14. English, Italian. PMID: 15263877.
8. Hoigne DJ, Stübinger S, Von Kaenel O, Shamdasani S, Hasenboehler P. Piezoelectric osteotomy in hand surgery: first experiences with a new technique. BMC musculoskeletdisord. 2006 Apr 12;7:36. Doi: 10.1186/1471-2474-7-36. PMID: 16611362; PMCID: PMC1459157.
9. Vercellotti, Tomaso, Piezoelectric bone surgery: a new paradigm / Batavia, IL: Quintessence Publishing Co, Inc, [2020]
10. Zadeh HH. Implant site development: clinical realities of today and the prospects of tissue engineering. J Calif Dent Assoc. 2004 Dec;32(12):1011-20. PMID: 15715378
11. Sclar AG. Strategies for management of single-tooth extraction sites in aesthetic implant therapy. J Oral Maxillofac Surg. 2004 Sep;62(9 Suppl 2):90-105. Doi: 10.1016/j.joms.2004.06.041. Erratum in: J Oral Maxillofac Surg. 2005 Jan;63(1):158. PMID: 15332186.
12. 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 Sep;32(9):994-9. Doi: 10.1111/j.1600-051X.2005.00809.x. PMID: 16104964.
13. Von See C, Rücker M, Kampmann A, Kokemüller H, Bormann KH, Gellrich NC. Comparison of different harvesting methods from the flat and long bones of rats. Br J Oral Maxillofac Surg. 2010 Dec;48(8):607-12. Doi: 10.1016/j.bjoms.2009.09.012. Epub 2009 Nov 3. PMID: 19889486.
14. Vercellotti T, Nevins ML, Kim DM, Nevins M, Wada K, Schenk RK, Fiorellini JP. Osseous response following resective therapy with piezosurgery. Int J Periodontics Restorative Dent. 2005 Dec;25(6):543-9. PMID: 16353529.
15. Schierano G, Canuto RA, Navone R, Peirone B, Martinasso G, Pagano M, Maggiora M, Manzella C, Easton M, Davit A, Trombetta A, Amedeo S, Biolatti B, Carossa S, Preti G. Biological factors involved in the osseointegration of oral titanium implants with different surfaces: a pilot study in minipigs. J Periodontol. 2005 Oct;76(10):1710-20. Doi: 10.1902/jop.2005.76.10.1710. PMID: 16253093.
16. Vercellotti T, Stacchi C, Russo C, Rebaudi A, Vincenzi G, Pratella U, Baldi D, Mozzati M,

Monagheddu C, Sentineri R, Cuneo T, Di Alberti L, Carossa S, Schierano G. Ultrasonic implant site preparation using piezosurgery: a multicenter case series study analyzing 3,579 implants with a 1- to 3-year follow-up. Int J Periodontics Restorative Dent. 2014 Jan-Feb;34(1):11-8. Doi: 10.11607/prd.1860. PMID: 24396835.

17. Da Silva Neto UT, Joly JC, Gehrke SA. Clinical analysis of the stability of dental implants after preparation of the site by conventional drilling or piezosurgery. Br J Oral Maxillofac Surg. 2014 Feb;52(2):149-53. Doi: 10.1016/j.bjoms.2013.10.008. Epub 2013 Nov 20. PMID: 24268822.
18. Preti G, Martinasso G, Peirone B, Navone R, Manzella C, Muzio G, Russo C, Canuto RA, Schierano G. Cytokines and growth factors involved in the osseointegration of oral titanium implants positioned using piezoelectric bone surgery versus a drill technique: a pilot study in minipigs. J Periodontol. 2007 Apr;78(4):716-22. Doi: 10.1902/jop.2007.060285. PMID: 17397320.
19. Al-Dajani M. Recent Trends in Sinus Lift Surgery and Their Clinical Implications. Clin Implant Dent Relat Res. 2016 Feb;18(1):204-12. Doi: 10.1111/cid.12275. Epub 2014 Oct 2. PMID: 25274014.
20. Seoane J, López-Niño J, García-Caballero L, Seoane-Romero JM, Tomás I, Varela-Centelles P. Membrane perforation in sinus floor elevation - piezoelectric device versus conventional rotary instruments for osteotomy: an experimental study. Clin Implant Dent Relat Res. 2013 Dec;15(6):867-73. Doi: 10.1111/j.1708-8208.2012.00447.x.Epub 2012 Feb 29. PMID: 22376212
21. 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. Int J Periodontics Restorative Dent. 2001 Dec;21(6):561-7. PMID: 11794567.
22. Van den Bergh JP, ten Bruggenkate CM, Krekeler G, Tuinzing DB. Sinusfloor elevation and grafting with autogenous iliac crest bone. Clin Oral Implants Res. 1998 Dec;9(6):429-35. Doi: 10.1034/j.1600-0501.1996.090608.x. PMID: 11429944.
23. Kasabah S, Krug J, Simůnek A, Lecaro MC. Can we predict maxillary sinus mucosa perforation? Acta Medica (Hradec Kralove). 2003;46(1):19-23. PMID: 12747535.
24. Sohn DS, Moon JW, Lee HW, Choi BJ, Shin IH. Comparison of two piezoelectric cutting inserts for lateral bony window osteotomy: a retrospective study of 127 consecutive sites. International Journal of Oral & Maxillofacial Implants. 2010 Jun 1;25(3).
25. Stacchi C, Vercellotti T, Toschetti A, Speroni S, Salgarello S, Di Lenarda R. Intraoperative complications during sinus floor elevation using two different ultrasonic approaches: a two-center, randomized, controlled clinical trial. Clin Implant Dent Relat Res. 2015 Jan;17 Suppl1:e117-25. Doi: 10.1111/cid.12136. Epub 2013 Aug 22. PMID: 23968289.
26. Majewski P. Autogenous bone grafts in the esthetic zone: optimizing the procedure using piezosurgery. Int J Periodontics Restorative Dent. 2012 Dec;32(6):e210-7. PMID: 23057065.
27. Sohn DS, Ahn MR, Lee WH, Yeo DS, Lim SY. Piezoelectric osteotomy for intraoral harvesting of

bone blocks. Int J Periodontics Restorative Dent. 2007 Apr;27(2):127-31. PMID: 17514884.

28. Pereira CC, Gealh WC, Meorin-Nogueira L, Garcia-Júnior IR, Okamoto R. Piezosurgery applied to implant dentistry: clinical and biological aspects. J Oral Implantol. 2014 Jul;40 Spec No:401-8. Doi: 10.1563/AAID-JOI-D-11-00196. PMID: 25020222.
29. Stübinger S, Stricker A, Berg BI. Piezosurgery in implant dentistry. Clin cosmetinvestig Dent. 2015 Nov 11;7:115-24. Doi: 10.2147/CCIDE.S63466. PMID: 26635486; PMCID: PMC4646478.
30. Amato F, Mirabella AD, Borlizzi D. Rapid orthodontic treatment after the ridge-splitting technique--a combined surgical-orthodontic approach for implant site development: case report. Int J Periodontics Restorative Dent. 2012 Aug;32(4):395-402. PMID: 22577645.
31. Simion M, Baldoni M, Zaffe D. Jawbone enlargement using immediate implant placement associated with a split-crest technique and guided tissue regeneration. Int J Periodontics Restorative Dent. 1992;12(6):462-73. PMID: 1298734.
32. Scipioni A, Bruschi GB, Calesini G, Bruschi E, De Martino C. Bone regeneration in the edentulous ridge expansion technique: histologic and ultrastructural study of 20 clinical cases. Int J Periodontics Restorative Dent. 1999 Jun;19(3):269-77. PMID: 10635173.
33. Gowgiel JM. The position and course of the mandibular canal. J Oral Implantol. 1992;18(4):383-5. PMID: 1298823.
34. Bovi M. Mobilization of the inferior alveolar nerve with simultaneous implant insertion: a new technique. Case report. Int J Periodontics Restorative Dent. 2005 Aug;25(4):375-83. PMID: 16089045
35. Metzger MC, Bormann KH, Schoen R, Gellrich NC, Schmelzeisen R. Inferior alveolar nerve transposition--an in vitro comparison between piezosurgery and conventional bur use. J Oral Implantol. 2006;32(1):19-25. Doi: 10.1563/1548-1336(2006)32[19:IANTIV]2.0.CO;2. PMID: 16526578.
36. Stübinger S, Landes C, Seitz O, Zeilhofer HF, Sader R. Ultraschallbasiertesknochenschneiden in der Oralchirurgie: eineubersichtanhand von 60 Patientenfällen [Ultrasonic bone cutting in oral surgery: a review of 60 cases]. Ultraschall Med. 2008 Feb;29(1):66-71. German. Doi: 10.1055/s-2007-963507. PMID: 18270888.
37. Salami A, Dellepiane M, Mora R. A novel approach to facial nerve decompression: use of Piezosurgery. Acta Otolaryngol. 2008 May;128(5):530-3. Doi: 10.1080/00016480701635175. PMID: 18421607.