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PIEZOELECTRIC SURGERY AS A BOON TO DENTISTRY: A REVIEW

Dentistry

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ABSTRACT

Dentistry has undergone significant advancement and has seen several changing concepts over a decade. One such novel innovation is piezosurgery. Piezoelectric bone surgery or otherwise known as piezosurgery is a novel technique invented by Professor Vercellotti in 1988 to overcome the limitations of traditional instrumentation in oral bone surgery by modifying and improving conventional ultrasound technology. It is a promising, meticulous, and soft tissue sparing system for bone cutting based on low frequency ultrasonic microvibrations. The absence of macro vibration makes the instrument more manageable and allows greater intraoperative control with a significant increase in cutting safety in the more difficult anatomical cutting zone. The present review compares piezosurgery with the traditional tools and emphasizes on its mechanism of action, instruments, biologic effects, advantages, and limitations, as well as its various applications in the field of dentistry.

KEYWORDS

piezoelectric surgery, piezosurgery, review

INTRODUCTION:

In recent years piezoelectric surgery is gaining popularity in field of dentistry. Nowadays piezosurgery plays a vital role because handling of delicate tissues can be performed with less risk for the patient and it offers a new possibility to do minimally invasive osteotomies. Ultrasound offers great potential in development of a non-invasive periodontal assessment tool that would offer great yield real time information, regarding clinical features such as pocket depth, attachment level, tissue thickness, histological change, calculus, bone morphology, as well as evaluation of tooth structure for fracture.[1]

Piezosurgical equipment can be used for retrograde preparation of root canal; it performs bone cutting with great precision facilitating ridge augmentation and ridge expansion, tooth extraction, ankylotic tooth extraction and surgical orthodontic surgeries. [2,3,4] The piezoelectric device is characterized by having ultrasonic micro vibrations with an average frequency of 25–29 kHz, an oscillation (amplitude) of 60–210 µm, and power up to 50 W, thereby allowing precise and tactile-controlled cutting only in mineralized structures without damaging soft tissue. [5,6]

HISTORY:

The term "piezo" originates from the Greek word piezein, which means, "to press tight, squeeze". The instruments used for ultrasonic cutting of bone create microvibrations which are the result of a piezoelectric effect, was first described by French physicists Jean and Marie Curie, in 1880 [7]. Catuna in 1953 developed an ultrasonic drill for cavity preparation on human teeth and published an article on the effects of ultrasound on dental hard tissues. [8], Mazzarow in 1960 reported evidence of an ultrasonic scalpel-like blade to directly cut osseous tissue. Mcfall et al., in 1961, evaluated the distinction of healing by comparison of rotating instruments and oscillating scalpel blade and found slow healing with no severe complication by use of these scalpel blades.[9] Volkov and Shepeleva in 1974 described cutting of hard tissue with ultrasonic vibrations as piezoelectric effect.

[10] In 1981, its application was described by Aro et al., [11] in orthopaedic surgery, and Horton et al., [18] in oral and maxillofacial surgery stated that bone regeneration was better using ultrasonic device. He evaluated the clinical utility of ultrasonic instrumentation in surgical removal of bone and observed mineralized tissue removal with ease and efficiency along with good acceptance by patients without any complications. Tomaso Vercellotti an Italian oral surgeon modified conventional ultrasonic technology. [12]

In 1997 Mectron and Tomaso Vercellotti developed the idea of piezoelectric bone surgery. In 1999, Dr. Tomaso Vercellotti invented piezoelectric bone surgery in collaboration with Mectron Spa and published in the year 2000.[13] In 2001, piezosurgery® was introduced. [Fig.1] In 2002, the device was approved for commercial use in Germany. In 2003, Vercellotti discovered the ideal frequency method for endodontic, orthopaedic, neurologic, periodontal, and oral and maxillofacial surgeries. [14,15] In 2005, the US Food and Drug Administration extended the use of ultrasonics in dentistry to include bone surgery.[16]

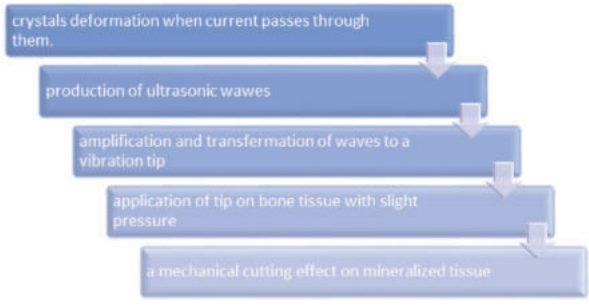
[Fig.1] Mectron piezosurgery®
(Courtesy: Mectron Dental India Pvt. Ltd.)

Parts Of Instrument:

The Piezosurgery® unit is composed of the main body, activated with a pedal, a handle, and a number of inserts with different shapes depending on the surgical need.

Mechanism Of Action:

The piezoelectric effect is the creation of electrical tension between crystal and ceramics like quartz to which a mechanical pressure is subsequently applied. The material will expand and then contract leading to ultrasonic vibration When electricity is applied, it leads to compression and expansion which occurs on reversing the direction. When crystal is placed in alternating electrical field, the crystal can alternate between compression and expansion producing a series of vibrations.



Piezoelectric effect:

Indications:

- In the field of dentistry,
- it is used for retrograde preparation of root canal,
- apicectomy
- ankylotic tooth extraction and orthodontic surgeries
- In periodontology
- Gingival cutting without bleeding.
- Root planing.
- Crown lengthening procedures.
- Removal of supragingival and subgingival calculus deposits. Smoothing of root surfaces by thorough removal of calculus and to regain positive bony margins

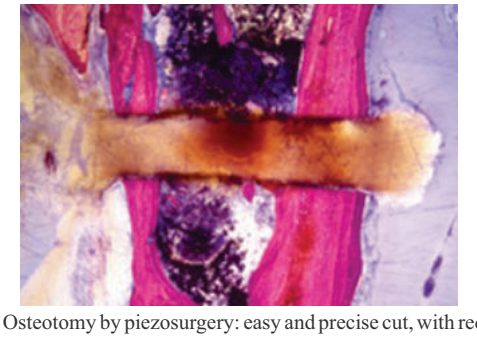
- Periodontal pocket lavage with simultaneous ultrasonic tip movement.
- Soft tissue debridement during periodontal flap surgery.
- Periodontal regenerative surgery.
- Bone harvesting techniques for autogenous grafts (Chips and blocks) – collection of particulate bone with a bone trap is a quality method to collect autogenous bone for correcting localized defects.
- ridge augmentation and ridge expansion.
- In the field of implantology and oral surgery
- for implant site preparation
- implant removal and bone harvesting and grafting and sinus lifts
- Alveolar ridge splitting and expansion before implant placement.
- Recontouring of alveolar crest.
- Nerve Transposition - Mental nerve repositioning.
- Sinus lift procedures.
- Lefort I osteotomy.
- Relocation of malposed implants.
- Peri-implantitis and calculus removal.

- Endodontics- Endodontic surgeries requiring osteotomy and in root-end preparations.
- Orthodontic surgery – microsurgery, osteotomy, and corticotomy.

It is also used for Minimally invasive caries therapy and ulcer debridement.

Contraindications:
- In certain diseases such as cardiopathy (heart disorders)
- uncontrolled diabetes and patient receiving radiotherapies.
- Also, it should be avoided on patients as well as operator with pacemakers or other implantable electronic devices. An electrosurgical knife could interfere with correct functioning of the device.
- should not be used where metal or ceramic prosthesis are given. The ultrasonic vibrations could lead to decementing of such prosthesis [28]

Biologic Effect On Bone:
There have been studies about the effect of piezoelectric surgery on bone and the viability of cells. Research has shown that the healing process after the surgical procedure is facilitated with the use of piezoelectric surgery and reduces inflammatory reaction when the graft is healing, which helps in stabilizing the live bone tissue after it has been grafted [22,27]



[Fig. 2] Osteotomy by piezosurgery: easy and precise cut, with reduced trauma and complications to the adjacent tissues (Courtesy: Mectron Dental- India Pvt Ltd)

Advantages:
Piezosurgery requires much less hand pressure, enhanced operator sensitivity and visibility (bloodless), acute tactile sense and control, does not cut soft tissue

producing less collateral tissue damage, which results in better healing.

It offers effortless surgical control, as it requires lesser force than rotational burs. The clinician has a better feel and precision in handling.

Precise cutting -
It vibrates within a width of 60-200mm at a modulated ultrasonic frequency without any increase in temperature, thus avoiding tissue damage.

Selective cutting action -
This vibration was optimal for cutting bone without harming adjacent tissues. The selective frequency minimizes the risk to adjacent soft tissues/nerves/vessels/ mucosa. This is similar to peeling the shell from a raw egg without damaging the thin membrane located just inside the shell.

Maximum intra-operative visibility – cavitation effect and pressurized irrigation.

Haemostasis due to cavitation effect-
It creates virtually, a bloodless surgical site. This is due to the coolant saline solution, which, on contact with the insert vibrating at ultrasonic speed, produces the cavitation phenomenon. This phenomenon consists of the formation of vapor bubbles within the coolant liquid. These bubbles implode, generating a shock wave. From a clinical standpoint, cavitation results in stopping blood from flowing out of the capillary during cutting. Bleeding starts again immediately after cutting ends.

Disadvantages:
- The main disadvantage is its slowness. Cutting very dense bone with ultrasound can take up to 4 times longer than with a rotary bur.
- It has less control of cutting depth, reduced sensibility and precision due to the vibrations.
- Tip breakage can be frequent which makes it necessary to maintain a stock of tips. The cost of ultrasonic osteotomy equipment is more than mechanical osteotomes.

CONCLUSION:
Piezosurgery is relatively new surgical technique, which can be used in a variety of surgical procedure to complement traditional oral surgical procedures, and in some cases, replace traditional procedures. It also had been found to have additional effects regarding bone healing, minimal intraoperative bleeding, etc., and seems to be more efficient in first phases of bone healing. In addition to its limitations, when used with their variable frequency and power, it serves as a platform for range of applications in periodontology, implantology, and various other oral surgical procedures, making it a highly effective tool in clinical practice.

REFERENCES

1. Bains, Vivek & Bains, Rhythm. (2008). Application of ultrasound in periodontics: Part II. Journal of Indian Society of Periodontology. 12. 55-61. 10.4103/0972-124X.44096.
2. Palti A, Hoch T. A concept for the treatment of various dental bone defects. Implant Dent 2002;11:73-8.
3. Vercellotti T. Technological characteristics and clinical indications of piezoelectric bone surgery. Minerva Stomatologica 2004;53:5.
4. Grenga V, Bovi M. Piezoelectric surgery for exposure of palatally impacted canines. J Clin Orthod 2004;38:446.
5. Robiony M, Polini F, Costa F, Vercellotti T, Politi M. Piezoelectric bone cutting in multipiece maxillary osteotomies: Technical Note. J Oral Maxillofac Surg 2004;62:6
6. 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.
7. Hoigne DJ, Stubinger S, Von Kaenel O, Shamdasani S, Hasenboehler P. Piezoelectric osteotomy in hand surgery: first experiences with a new technique. BMC Musculoskelet Disord. 2006; 7:36.
8. Catuna MC. Sonic Surgery. Ann Dent 1953;12:100-29
9. Mcfall TA, Yamane GM, Burnett GW. Comparison of cutting effect on bone of ultrasonic cutting device and rotary burs. J Oral Surg 1961;19:200-9
10. Volkov MV, Shepeleva IS.The use of ultrasonic instrumentation for the transection and uniting of bone tissue in orthopaedic surgery. Reconstr Surg Traumatol. 1974; 14 (0): 147-52.
11. Aro H, Kallioniemi H, Aho AJ, Kellokumpu-Lehtinen P. Ultrasonic device in bone cutting. A histological and scanning electron microscopical study. Acta Orthop Scand. 1981; 52(1):5-10.
12. Horton JE, TarpleyTMJr, Jacoway JR. Clinical applications of ultrasonic instrumentation in the surgical removal of bone. Oral Surg Oral Med Oral Pathol. 1981; 51(3):236-42.
13. Vercellotti T, Paoli SD, 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 Perio Rest Dent. 2001; 21:561–67.
14. Vercellotti T. Piezoelectric surgery in implantology: A case report – A new piezoelectric ridge expansion technique. Int J Periodont Restorative Dent 2000;20:359-65.
15. Walsh LJ. Piezosurgery: An increasing role in dental hard tissue surgery. Aust Dent Pract 2007;18:52-6.
16. 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;40:401-8.
17. Thomas J. piezoelectric ultrasonic bone surgery: Benefits for the interdisciplinary team and patients. Dent India 2008;2:20-4
18. Esha agarwal, Sujata SurendraMasaamatti, Ashish kumar, Escalating role of Piezosugery in dental therapeutics, J Clin diagn res. 2014 oct ;8(10): ZE08- ZE11.
19. Laurence J Walsh ,Piezosurgery: an increasing role in dental hard tissue surgery, Australasian Dental Practice 18 (5), 52-56, 2007
20. Chopra P, Chopra P. Piezosurgery and its applications in Periodontology and Implantology. International Journal of Contemporary Dentistry. 2011;2(4): 16-24. (http://edentj.com/index.php/ijcd/article/view/404/251).
21. Yaman Z, Suer BT. Piezoelectric surgery in oral and maxillofacial surgery. Annals of

Oral and Maxillofacial Surgery. 2013; 1(5):1-9
22. Sohn DS, Ahn MR, Lee WH, Yeo DS, Lim SY. Piezoelectric Osteotomy for Intraoral Harvesting of Bone Blocks. Int J Periodontics Restorative Dent. 2007 (2)27:127–31.
23. Claire S, Lea SC, Walmsley AD. Characterisation of bone following ultrasonic cutting. Clin Oral Investig. 2013; 17(3): 905-12.
24. Mathai Thomas, Uttam akula, Kranti k. R. Ealla, Nirosha gajjada, Piezosugery: a boon for periodontics, Journal of International Society of Preventive and communitive dentistry 2017 Jan-feb 7(1) :1-7
25. V.K. Vignesh, Dr. M. Thamaraiselvan, piezoelectric surgery in periodontal therapy, Research. J. Pharm and tech 9(1): jan, 2016
26. Dr.uma laxmi, Dr. Sumit kaushal, Piezosugery: unlocking the treasure box, J. Periodontal Med Clin Practice 2016;03:80-86.
27. Happe A. Use of a piezoelectric surgical device to harvest bone grafts from the mandibular ramus: report of 40 cases. Int J Periodontics Restorative Dent 2007; 27:241–9.
28. Horton JE, Tarpley TM Jr, Jacoway JR. Clinical applications of ultrasonic instrumentation in the surgery removal of bone. Oral Surg Oral Med Oral Pathol 1981 Mar;51(3):236-242.