REVIEW ARTICLE

PIEZOSURGERY: A BOON FOR PERIODONTOLOGY

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ABSTRACT

The last decade of dentistry has witnessed the emergence of novel family of ultrasonic instruments known as Piezosurgery that has revolutionized the treatment options for maxillofacial surgery.Itwas invented by Vercellotti and developed by Mectron Medical Technology. Traditionally, osseous surgery was performed using hand instruments and various rotary instruments with different burs. However, they are not sans demerits.

Piezosurgeryis used for selective cutting of bone depending on bone mineralization, without damaging the adjacent soft tissue (e.g. vessels, nerves or mucosa), creating a clean operating field, and cutting with sensitivity without the generation of heat. The present review emphasizes on Piezosurgery's mechanism of action, instruments, biologic effects, advantages, and limitations, as well as its applications in Periodontology.

Key Words: Piezosurgery, Periodontology,surgery.

INTRODUCTION:

Last few decades of the twentieth century have witnessed rapid development in various dental surgical techniques paving a path for painless and less traumatic dentistry. Apart from other modalities, ultrasound has been known to cut tissue since almost two and a half decades.[1] However, standard clinical applications of this technique in routine dental practice have seen the light of the day only inthe past decade.

One primary objective of osseous surgery is to eliminate osseous deformities and produce a physiologic parabolic contour.[2] Conventionally, manual and motor driven instruments have been used for the same. While manual instruments offer good control in removal of small amount of bone, they are difficult to control in the areas of more mineralization like cortical bone. To overcome the limitation of manual instruments, motor driven instruments can be employed. However, they generate consequential heat in the cutting area which must be managed by copious irrigation. Overheating of adjacent tissue can be minimized by reducing the rotational speed, which reduces frictional heat but in turn also dampens the cutting efficiency.[3]Also the noise produced by traditional motor driven instruments could cause anxiety and stress in patients while the surgery is being performed.[4] Another shortcoming of motorized cutting tools is reduced tactile sensitivity. Slower speed of motorized instruments creates a need for increased application of pressure on operator's part, which increases macrovibration of the cutting tools which further ebbs the sensitivity. This poses particular problems when cutting over an area of dense cortical bone into either

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trabecular bone or soft tissue (for example, drilling an osteotomy above the mandibular canal or creating a lateral window for sinus grafting.[3]

From a mechanical standpoint, the burs or twist drills cause lamellar fracturing in areas adjacent to the cut surface and the deposition of large bone fragments and debris in the endosteal spaces. This observation is thought to be responsible for the inflammatory process that takes place in the immediate postsurgical wound healing and for the delay of osteogenesis observed in these wounds.[5]

The idea of Piezosurgery was conceived to overcome the limitations of traditional bone cutting instruments and to achieve the most effective treatment with least morbidity.

What is piezosurgery??

Piezosurgery is a fairly new method for bone recontouring and removalthat utilizes the principle of ultrasonic vibration.The basic technology used is the piezoelectric phenomenon, first described by Jean and Marie Curie in 1880.[3]The term "piezo" originates from the Greek word piezein, which means, "to press tight or to squeeze."[6]Piezoelectric effect is the property of certain materials to produce an electric charge in response to applied mechanical stress.[7]

Historical background

1997- Mectron and Vercelloti developed the idea of Piezoelectric bone surgery
1998- First bilateral sinus lift surgery performed
1999- Vercelloti coined the term "piezosuegery'
2000- 1^{st} generation of Piezosurgery device introduced
2004- 2^{nd} generation of Piezosurgery device introduced
2005- 1^{st} implant site preparation done using Piezosurgery
2009- 3^{rd} generation of Piezosurgery device introduced

Table 1 showing a brief history of piezosurgery

Jean and Marie Curie (1880) first discovered that certain crystals produced electrical current under mechanical pressure (piezoelectricity). It was the pioneering thought of Tomaso Vercelloti based on the principle of piezoelectricity that paved path to piezosurgery as we know it today. He proposed the idea of using sharpened instruments fitted on ultrasonic device for ablation to perform periradicular osteotomy to extract an ankylosed tooth.[4]

Piezosurgery has gradually gained acceptance and popularity among dental and medical fraternity because it allows precise, clean, and smooth cutting, all with excellent visibility and provides a more favorable osseous repair and remodeling than harvesting with carbide or diamond burs.[8]

Mechanism

The most commonly used piezoelectric crystals are Rochelle salt, quartz, and certain types of ceramics.

Compression is observed in piezoelectric crystals when electrical charges are applied to the face of the crystals and expansion occurs when the direction of electric charge is reversed.It is possible to achieve alternate compression and expansion when the piezoelectric crystals are placed under an alternating electric field thus producing a series of vibrations.[9] This results in an oscillating shape change of the crystal which is then passed onto the working tip.The resultant vibration produces the tip movement that is principally linear in direction and when this series of vibrations are conducted through a piezoelectric transducer, higher efficiency is obtained (Fig 1). The operating frequency of piezoelectric unit is 25-50 KHz.[6]

Fig 1: Piezosurgery tip vibrations

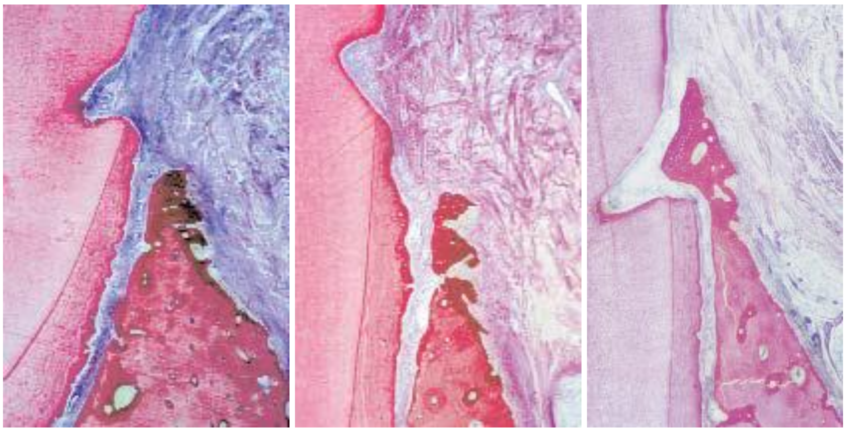
Advantages

The modulated ultrasonic frequency of piezosurgery unit facilitates highly accurate and safe cutting of hard tissue. The microvibrations are optimally adjusted(60 to 200 mm/sec) to target only mineralized tissue thus leaving the nerves, vessels, and soft tissue unharmed. There is a low bleeding tendency because of the selective and thermally harmless nature of the piezosurgery instrument. Precise, clean, and even cut geometries of bone is achieved during surgery due to the explicit nature of the instrument. The difference in time requirement for surgical procedures using the piezosurgery instrument in comparison with the conventional drill is negligible. Postoperatively, excellent wound healing, with no nerve and soft tissue injuries, is observed.[10]

Compared with traditional rotary instrumentation, piezosurgery requires much less hand pressure. This results in enhanced operator sensitivity and control, indicating that the clinician can develop a better ‘feel’ and precision for the cutting action because of microvibration of cutting tip.[3]

Piezosurgery has therapeutic features that include a micrometric cut (precise and secure action to limit tissue damage, especially to osteocytes), a selective cut (minimum soft tissue damage), and a clear surgical site (the result of the cavitation effect created by an irrigation/cooling solution and oscillating tip). A “selective cut” enables the clinician to cut hard tissues while sparing fine anatomical structures (e.g., schneiderian membrane, nerve tissue) and it is possible because the instrument's tip vibrates at different ultrasonic frequencies, since hard and soft tissues are incisedat different frequencies.[11] An oscillating tip drives the cooling-irrigation fluid, rendering it possible to obtain effective cooling as well as better visibility (via cavitation effect) compared to conventional surgical instruments (rotating burs and oscillating saws), even in deep spaces. As a result, implantology surgical techniques such as bone harvesting (chips and blocks), crestal bone splitting, and sinus floor elevation can be performed with greater ease and safety.[12]

Osseous Response Following Resective Therapy with Piezosurgery The effects of mechanical instruments on the structure of bone and the viability of cells are important in regenerative surgery.[13] Vercelloti and colleagues carried out a histological analysis to assess the response of bone after respective therapy and compared ostectomy sites created by carbide bur (CB), diamond bur (DB) and Piezosurgery tips (PS). Albeit by day 28, the surgical sites treated by all three instruments demonstrated an increased bone level and regeneration of cementum and periodontal ligament, however, by day 56, the surgical sites treated by CB or DB showed bone loss, versus a bone gain in the PS-treated sites (fig 2). Thus, it is evidentthat PS provided more positive osseous repair and remodeling than CB or DB when surgical ostectomy and osteoplasty procedures were performed. They thus concluded piezosurgery could be regarded as being efficacious for use in osseous surgery.[2]



(a) (b) (c)

Histologic sections[2]of biopsies at 56 days following surgical procedures evidenced no bone loss apical to the notches, but the section treated by PS (c) demonstrated more coronal growth of bone than the sections treated by CB (a) or DB (b)

Equipment

The device contains a main switch, to which a hand piece and a foot switch are connected.The former supplies power and has holder for hand piece and irrigation fluids. The main unit consists of a platform and a control panel along with a digital display and keypad. Frequency of 25–29 kHz is present with a series of inserts of different form along with a linear vibration ranging from 60–200 µm. The power of the device is around 5 W. The unit offers three different power levels from a clinical application point of view. Low mode for orthodontic surgery and apico endocanal cleaning; high mode for cleaning and smoothing the radicular surface; and boosted mode in osseous surgery for performing osteotomy and osteoplasty.[6]

OPERATING MODE[5]

The unit has a display that allows the operator to select either the BONE or ROOT operating modes. The BONE cutting mode is used to cut bone with selections that are specific to bone type or density. The ROOT mode is used to shape, debride, and smooth root surfaces (both external: periodontal and internal: endodontic).

<u>Bone Operating Mode</u>

Cortical Bone: The basic low ultrasonic frequency (30 kHz) is overmodulated by sound waves for cutting and removing small cortical bone fragments.

Spongy Bone: The basic low ultrasonic frequency is overmodulated by sound waves that are slower than those for cortical bone, which is better for cutting and removing cancellous bone fragments.

Root Operating Mode

Periodontal Surgery: The low ultrasonic frequency without overmodulation is set at an ideal power level for scaling, debridement, and root planing.

Endodontic Surgery: The ultrasonic frequency is set at an ideal power level for retrocanal and intracanal debridement after root canal treatment.

PIEZO INSERTS[5] (Fig 3)

The mechanical action of bone cutting takes place due to the linear microvibrations of inserts with a variable range from 20 to 80 µm, depending on efficiency. Piezosurgery inserts are classified based on their functional and clinical characteristics.

Fig 3: Piezo inserts

Functional Classification

Sharp: These inserts have sharp ends for osteotomy and osteoplasty whenever a fine and well defined cut in the bone is desired. They are made of nitride titanium steel and they are gold in color.

Smoothing: These nitride titanium inserts have diamond coated surface which produces a smoothening action that is generally used to complete the cut near soft tissue, for example preparing a sinus window.

Blunt: These steel colored inserts are characterized by rounded ends and are generally used to refine the cut in contact with soft tissue. In Periodontology, these inserts are used for root planing.

The inserts described in the functional classification as sharp, smoothing, and blunt have clinical classification codes that relate to their specific use.

Clinical Classification

OT: The identification code for inserts used to perform osteotomy is *OT* followed by a number.

OP: The identification code for inserts used to perform osteoplasty is *OP* followed by a number.

EX: The identification code for inserts used to perform extraction is *EX* followed by a number.

IM: The identification code for inserts used to perform implant site preparation is *IM* followed by a number.

Limitations

• Adequate dexterity is required for this type of procedure with a different learning curve.

• Increase in operative time compared to traditional cutting instrument.

• Difficulties encountered in deeper osteotomies sites because lack of insert of appropriate length and thickness to avoid the increasing pressure of the hand preventing microvibration of the insert.

• Inserts get worn away very rapidly, and hence, it is recommended not to go beyond ten uses in bone surgery because it may break or cause damage to tissues by uncontrolled heat.[13]

• Expensive instrument.

Uses of Piezosurgery

- Crown lengthening technique.
- Scaling and root planing (Fig 4)
- Resective and Regenerative Surgery
- Osteotomy and Corticotomy (Fig 5)
- Maxillary sinus lift (Fig 6a, b)
- Ridge expansion (crestal splitting) (Fig 7a, b)
- Harvesting techniques
- Implant site preparation (Fig 8a, b)
- Apicoectomy (Fig 9a,b)

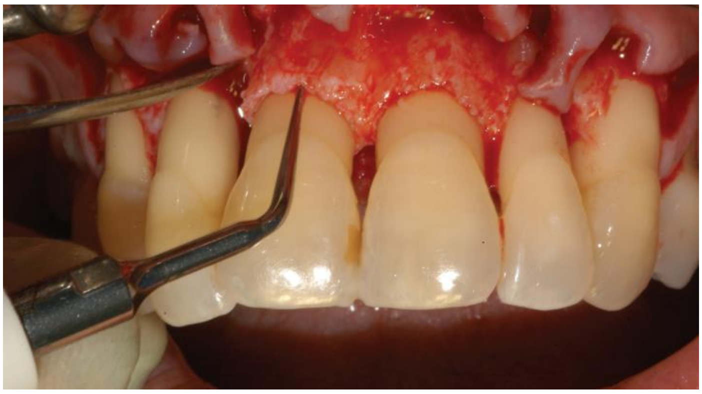


Fig 4: Root planing using piezosurgery blunt insert[5]

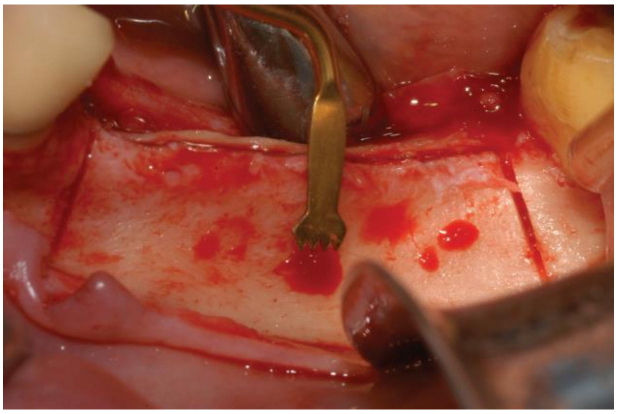


Fig 5 : Horizontal and vertical osteotomies prepared with piezosurgery insert[5]

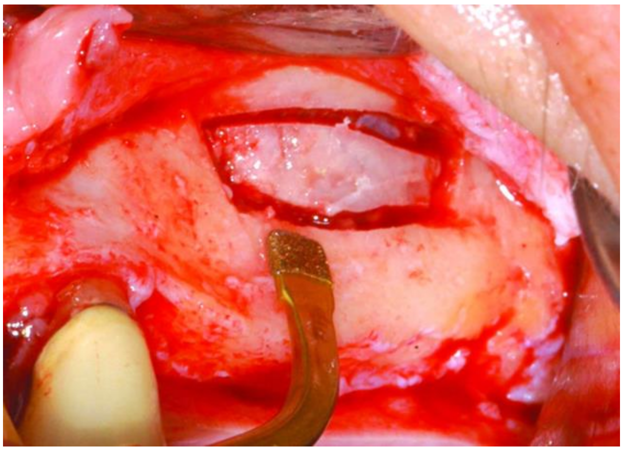


Fig 6: Sinus lift using Piezosurgery tip[15]

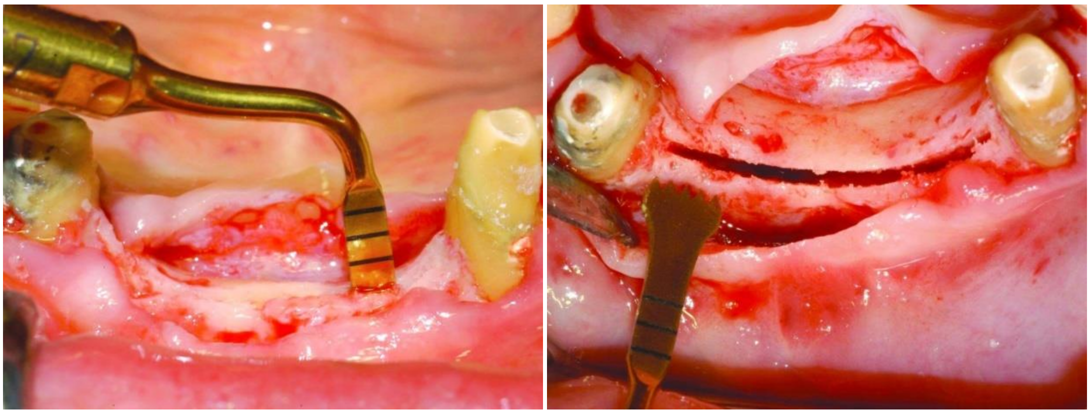


Fig 7 a,b: ridge splitting[15]

Fig 8a: Implant site preparation[5] Fig 8b: completed implant site preparation[5]

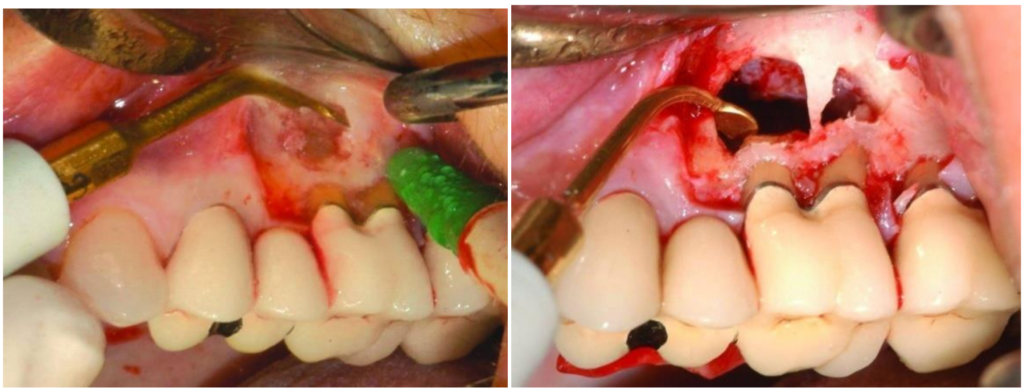


Fig 9 a,b: Apicoectomy[15]

CONCLUSION:

Piezoelectric surgery is an innovative technique in bone surgery. Because of its highly selective and accurate nature, with its cutting effect exclusively targeting hard tissue, its use may be extended to more complex oral surgery cases, as well as to other interdisciplinary problems. The new surgical protocol, using piezoelectric instruments to perform the sinus lift radically reduces the incidence of membrane perforation. It also allows expansion of deficient ridges The technique therefore allows a much greater success rate than has been previously possible with any other method of advanced implant surgery. Apart from these advanced periodontal procedures, a number of conventional periodontal surgeries involving ostectomy and osteoplasty find application of piezosurgery. Piezosurgery has allowed the performance of a surgical technique that greatly reduces complications and operating time and therefore the morbidity of the patient. These advances mean that more dental surgeons will be able to perform advanced implant surgery, making implants an even more attractive alternative for patients with insufficient volume of maxillary crestal bone. Piezoelectric surgery could further simplify sinus surgery in the near future because it offers a new technique in bone harvesting.

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