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PIEZOSURGERY IN PERIODONTICS - A REVIEW

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Abstract : Piezoelectric technology has emerged as a significant advancement in periodontics, offering precise and minimally invasive options for various periodontal procedures. This article explores the application of piezoelectric devices in periodontal surgery, scaling, and root planing, emphasizing their advantages over traditional methods. The technology's ability to selectively target mineralized tissues while preserving soft tissues leads to improved patient outcomes, reduced postoperative discomfort, and faster recovery times. Additionally, the article discusses the potential of piezoelectric instruments in enhancing surgical precision and reducing intraoperative complications, thereby advancing the standard of care in periodontal therapy.

IndexTerms - Piezosurgery, bone cutting, implantology, vibrations

INTRODUCTION

The word “piezo” originates from the Greek word “piezein”, which means pressure. It was created in 1988 by Italian oral surgeon Tomaso Vercelloti to enhance and alter conventional ultrasonic technology in order to get over the limitations of conventional apparatus in oral bone surgery .[1]

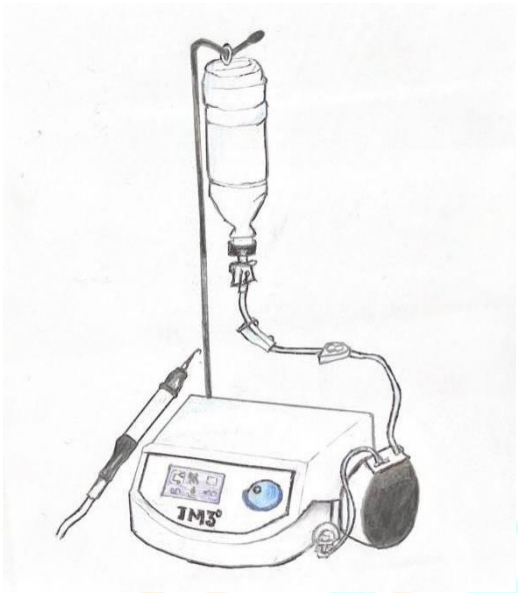
The method involves the deformation of crystals and ceramics by electric fluxes, which causes them to oscillate and produce ultrasonic frequency movements that can precisely cut bone structures without injuring soft tissue. The handpiece is powered by microvibrations with an amplitude of 60 to 210 mm when the frequency is adjusted between 25 and 30 kHz. Although the product's primary goals are soft tissue preservation and bone removal, certain models include a modified setting that can be used to remove lesions from soft tissues. Low bleeding tendency is a result of this instrument's selective and **thermally innocuous nature.[1]**

HISTORICAL BACKGROUND

Jacques and Pierre Curie discovered the piezoelectric phenomenon in 1880. When Catuna initially described the cutting effects of high-frequency sound waves on the tooth hard tissue in 1953, the field of dentistry saw a surge of interest in ultrasonics, primarily in the fields of periodontology and endodontics Zinner initially used ultrasonic scalers in the periodontal process in 1955. These devices had a single, large universal tip, but today there are several site-specific, smaller tips available.[2]

Despite the fact that Horton and colleagues initially described ultrasonic osteotomies over 20 years ago, this method was not followed for a long time. Vercellotti et al. reintroduced this strategy for soft tissue and nerve preservation surgery in 2000, overcoming the drawbacks of using conventional equipment in oral bone surgery. First reports of it concerned sinus grafting, alveolar crest expansion, and preprosthetic surgery.[2]

PARTS OF THE INSTRUMENT

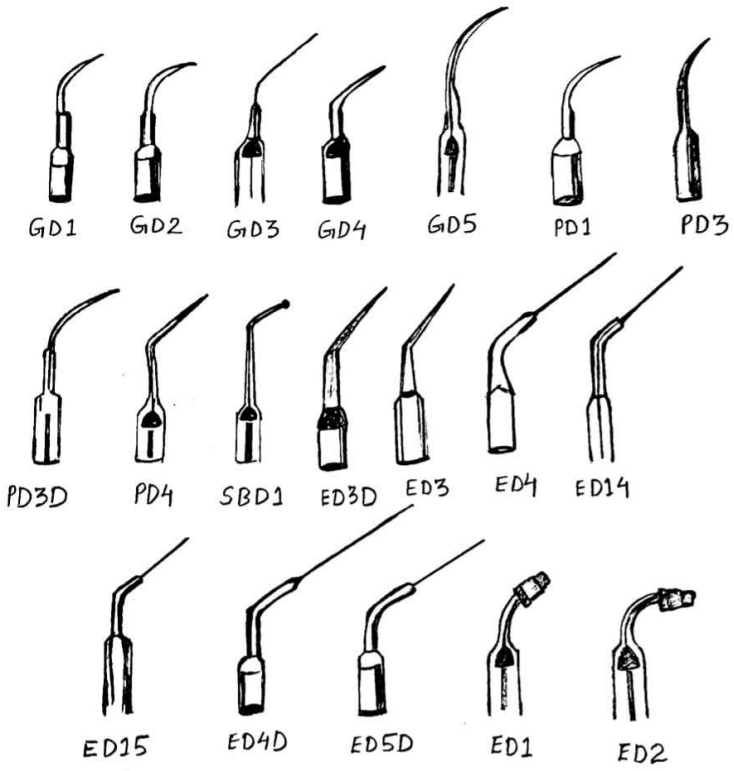


Piezo electronic device

The hand piece and foot switch that are connected to the main power unit are the typical components of piezoelectric devices. This has a hand piece holder and is filled with irrigation fluids that, when diffused as an aerosol, produce an adjustable jet of 0–60 ml/min through a peristaltic pump, clearing debris from the cutting area and preserving a blood-free operating area due to cavitation (the formation of imploding bubbles) in the irrigation solution. This increases visibility, especially in intricate tissue regions.
In most cases, the pressure load on the tip triggers an automated regulation of the instantaneous frequency. Aside from the pressure that is applied, the user controls the pulse frequency (if it is available), the cooling fluid delivery rate, and the applied power, which varies depending on the instrument and can range from 3 to 16 W to 90 W. The majority of equipment allow you to control power by choosing the kind of bone to cut or the operation to be carried out. Precise microabrasive incision is ensured by the peak-to-peak amplitude of tip oscillations, which are usually in the range of 30-200 mm in the plane perpendicular to the working piece's shaft (certain instruments oscillate along the shaft entirely or in addition).[2]

APPLICATION	TIP MODELS
Supragingival scaling	GD1, GD2, GD3, GD4, GD5
Subgingival scaling	PD1, PD3, PD3D, PD4
Endodontics	ED3, ED3D, ED4, ED14, ED15, ED4D, ED5D, ED1, ED2
Cavity preparation	SBD1

- GD - General debridement or General Dentistry
- PD - Periodontal deep or Periodontal debridement
- ED - Endodontic or Exodontia
- SBD - Subgingival Biofilm Debridement



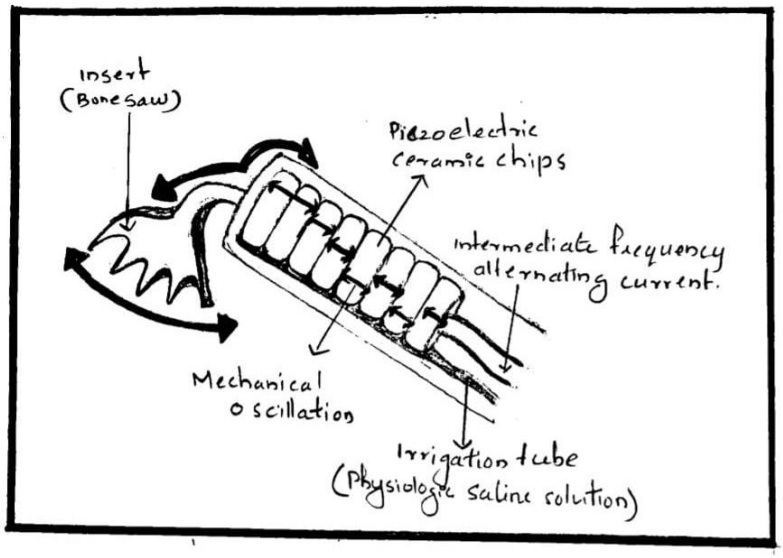
Piezo scaling tips

MECHANISM OF ACTION

In piezoelectric ultrasonic technology, an electric current is applied from a generator to piezoceramic rings, causing the rings to deform. The ultrasonic output is produced by a transducer, amplifier, or both vibrating in response to the movement caused by the ring's deformation. These waves traveled to the tip of the hand piece, also known as an insert, where the longitudinal movement caused microscopic bone fragment breaking, which in turn caused cutting of the osseous tissue.[6]

Ultrasonic testing is based on the conversion of electrical pulses to mechanical vibrations and the subsequent conversion of returned mechanical vibrations back into electrical energy. The transducer's active element is what drives the conversion of electrical energy into acoustic energy and vice versa. The active element is essentially a polarized material with electrodes attached to two of its opposite faces. The polarized molecules will align themselves with the electric field when it is applied across the material, creating induced dipoles inside the material's crystal or molecular structure. The material's dimensions will alter as a result of the molecules alignment. This phenomenon is called electrostriction. Furthermore, when a mechanical force is applied to a permanently polarized material, like quartz (SiO_2) or barium titanate ($BaTiO_3$), the substance will change dimensions and generate an electric field. The piezoelectric effect is the name given to this phenomenon. [4]

Piezosurgery handpiece with a piezoelectric ceramic chip



APPLICATION IN DENTISTRY

1. ORAL SURGERY
a. Root extraction
b. Apicectomy
c. Cystectomy
d. Distraction Osteogenesis
e. Sinus lift
f. Enucleation of jaw cyst
g. Removal of odontogenic tumors
h. Jaw resection
i. Treatment of TMJ ankylosis

2. ORTHODONTICS
a. Palatal impacted teeth removal
b. orthodontic corticotomy
c. orthognathic surgery

3. ENDODONTICS
a. Root-end resection
b. Nucleation of radicular cyst
c. Root end cavity preparation
d. Bone tissue management

4.PERIODONTOLOGY AND IMPLANTOLOGY
a. Preparation of implant site
b. Sinus floor elevation
c. Edentulous ridge splitting
d. Lateralization of the inferior alveolar nerve
e. Relocation of malpositioned implants
f. Osteotomy and osteoplasty techniques
g. Reconstructive procedures
h. Bone harvesting for regenerative surgery
i. Root debridement
j. Scaling and Root planing[5]

APPLICATION OF PIEZO IN PERIODONTOLOGY AND IMPLANTOLOGY

- Preparing the implant site

Overheating during implant-site preparation has a deleterious impact on the osseointegration process . Temperature generated differ in relation to various tips; the lowest temperature is produced by smooth tips. The method used for the cutting and the unique characteristics of the bone itself are two further elements that will affect the temperature rise[8]. A set of specifically produced piezosurgery inserts can be used to perform a novel kind of implant site preparation. Piezosurgical site preparation allows for the selective enlargement of a single socket wall. This is referred to by Vercellotti as "differential ultrasonic socket preparation."[3]

- Sinus Floor elevation

the transalveolar method of piezoelectric surgery without a mallet for sinus floor elevation, known as the piezoelectric internal sinus elevation (PISE) technique. The modified osteotome-mediated sinus floor elevation method is known as PISE. Using a mallet, osteotome-mediated sinus floor elevation raises the sinus membrane and breaks the sinus floor. Positional vertigo may result from using this procedure on the patient. Postoperative positional vertigo may be less likely using the PISE approach since it breaks the sinus floor and elevates the sinus membrane without the need for a mallet[9].Treating vertical deficits in the posterior maxilla usually involves the sinus floor elevation. Most often, lateral access is used. A modified Caldwell-Luc approach is used to prepare the Schneiderian membrane. During the window preparation or elevation step of this treatment, there is a danger of membrane perforation.[1] The use of piezosurgery offers the advantages of dealing solely with hard tissue and not soft tissue, as well as precise bone cutting by micrometric bone cutting.[11]

- Ridge splitting methods

Oscillating saws and rotating chisels were the tools used in traditional ridge splitting. These methods required more time, were more technically challenging, and increased the possibility of harming nearby soft tissues and teeth. With a reduced chance of thermal necrosis and the ability to create a vertical cusp without harming nearby soft tissues or teeth, the piezo has made this treatment simpler and safer to carry out.[1]

- Scaling and root planing

To remove deposits from all surfaces, the piezosurgery ultrasonic scaler is set to function On/Mode Periodontics (ROOT) and uses the inserts PS1 and PP1 applied at a medium power of two for 15 seconds. The working strokes were perpendicular to the tooth axis, whereas the movements were parallel to it. Compared to the traditional magneto-strictive ultrasonic scaler, the piezoelectric device seems to yield better results in terms of roughness and less damage to the root surface.[4]

- Bone grafting

The availability of sufficient residual bone volume is a prerequisite for the placement of dental implants. When only a small amount of bone is needed, autogenous bone grafts from the chin or ramus are the most common alternatives[3]. The iliac crest, skull, and mandible are the typical donor sites for block transplants[10]. Large surgical access is frequently required during these procedures in order to gather the optimal amount of bone and to safeguard the surrounding soft tissues and important anatomical structures. Because piezosurgery requires the active tip to have a low amplitude in a small access area, significantly reducing intraoperative bleeding, it is safer and more precise in this regard. The sensitivity of the method is also very helpful for delicate surgeries. With ultrasonic surgery, there is virtually little chance of complications such as accidental tooth root damage or penetration into the mandibular canal[12].

- Lateralization of inferior alveolar nerve

It is necessary to use a tool that lowers the possibility of nerve damage when performing osteotomies. This is made feasible by the piezoelectric device's cavitation effect, surgical control, and tip form, which assist the surgeon in procedures near the inferior alveolar nerve. If implants are intended for an edentulous jaw, this process serves as an alternative to the augmentation technique. This can be done by using the piezoelectric device to make incisions that allow the cortical lateral bone lid to be replaced over the neurovascular bundle. The nerve structure is safeguarded by this process during nerve retraction and transposition.[7]

- Relocation of malpositioned implants
  A relatively recent surgical method called "implant relocation" is used to shift integrated implants and the surrounding bone into a more desirable position. For this treatment, piezosurgery has the benefit of allowing for maximum intra-operative control, which guarantees a precise cut with little bone ablation. Additionally, compared to wounds made with burs or saws, the healing reaction is probably going to be more positive.[5]

- Osteotomy and osteoplastic techniques
  This method is especially helpful for performing multiple maxillary surgery and preserving the viability of the teeth in the osteotomy line. Piezo makes precise cuts while protecting delicate tissues like the brain, dura mater, and palate mucosa[1]. The Piezosurgery system is used for ultrasound-assisted osteotomies. Because it uses modulated ultrasound to function, the device may produce micromovements[13].

ERGONOMICS

The foundation of surgical motions is experience and repetition of the movements; this is the main factor to be considered when beginning to utilize PS. Since piezoelectric cutting uses microvibrations, the surgical handling needed in this procedure is actually entirely different from that of drills and oscillating saws. Therefore, it follows that increasing hand pressure (as with bone drills or saws) will not increase cutting capacity because, above a certain point, increased pressure prevents the insert from microvibrating; instead, the energy not used for cutting is converted to heat, which, if it persists, can injure tissue.As a result, it's essential to adjust the pressure based on the insert's speed to prevent surgical obstacles.[2]

ADVANTAGES

1) During the initial stages of bone healing, piezoelectric bone surgery appears to be more effective.
2) Micrometric cutting action: Accurate cut without causing harm to nearby structures
3) Selective cutting action: cutting through tissue does not harm nearby soft tissue
4) It expedites the process of bone regeneration and repair.
5) Excellent surgical device control
6) Minimal operational invasion and selective cutting
7) Lessened stress from trauma
8) Less post-intervention pain and no chance of developing emphysema.[2]

DISADVANTAGES

1) The increased operating time needed for bone preparation is the primary drawback of the piezosurgery equipment.
2) Because tips can break easily, it's important to keep a supply on hand.
3) The price of mechanical osteotomes is lower than that of ultrasonic osteotomy equipment.
4) In addition, learning the skill is challenging.[2]

CONCLUSION

Piezo surgery is a new surgical technique for bone surgery with many clinical applications in dentistry. When compared to conventional hard and soft tissue methods that use rotating instruments, piezoelectric devices are a unique ultrasonic technology for safe and successful osteotomy or osteoplasty because of the lack of macro-vibrations, ease of use and control, and safer cutting. Thus, piezosurgical device is a novel invention with variable frequency and variable power and is a platform for wide range of applications in minimally invasive caries therapy, prosthodontics, periodontology, oral surgery and medicine making such a unit a highly effective tool in clinical practice.

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