

# Piezo Surgery: A Boon For Modern Periodontics

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### Abstract

Piezosurgery is a novel technique that uses piezoelectric ultrasonic vibration to provide safe and precise osteotomy. Recently this technique has gained importance because of its ease of use and safety. Professor Vercelloti in 1988 invented this technique known as piezosurgery or piezoelectric bone surgery. The piezoelectric effect occurs when an electric current is passed around a stack of crystals and they start to vibrate at a modulated ultrasonic frequency of 24-29 Hz. and microvibration amplitude between 60 and 200 mm per second. This technique allows a clean precise and controlled cut of bony structures without causing destruction of soft tissue. This article focuses on the broad range of applications of this novel technique in Periodontology.

### Introduction

The past two decades has seen rapid development in various dental surgical techniques. Traditionally, osseous surgery was performed by using hand instruments and various rotary instruments with different burs which required external copious irrigation because of the production of heat. Using these instruments, a pressure was also exerted with a limitation in the case of brittle bone. In order to overcome the limitation of traditional techniques in oral bone surgery a relatively new technique for osteotomy and osteoplasty that uses ultrasonic vibrations was introduced by Professor Tomaso Vercelloti in 1988 and developed by Mectron Medical Technology.<sup>1</sup> This device is known as Piezoelectric device and the surgery is known as Piezosurgery. The piezosurgery device consists of a novel piezoelectric ultrasonic transducer powered by ultrasonic generator capable of driving a range of resonant cutting inserts.<sup>1</sup> The philosophy behind the development of piezoelectric bone surgery is based on two fundamental concepts i.e. minimal invasive surgery, which improves tissue healing and reduce discomfort to the patient and the surgical predictably which increases treatment effectiveness.<sup>2</sup>

### Historical background

The term “piezo” originates from the Greek word “peizein” which means “to press tight, squeeze”. Jacques and Pierre Curie first discovered piezoelectricity in the year 1880, when pressure is applied on crystals, ceramics or bone electricity is created. Dr. Tomaso Vercellotti, an Italian periodontist felt the need to change the osseous surgery procedures to make the results more predictable, improve healing, minimize trauma and provide greater safety for patients. In year 1999 he invented piezoelectric bone surgery in collaboration with Metron Spa. This technology has been used commercially in Europe since 2000. In 2005, the US Food and Drug administration extended the use of ultrasonics in dentistry to include bone surgery.

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### 3. Parts of Piezoelectric Device

The device consists of a hand piece and a foot switch that are connected to a main unit, which supplies power and has a holder for hand piece and irrigation fluids. The unit consists of hand piece, foot switch, ultrasound, control, dynamometric wrench and peristaltic pump. This piezoelectric device works in the range of 25-29KHz and can be modulated further by 30 Hz digital modulation and series of inserts of different forms with a linear vibration ranging from 60 to 200 $\mu$ m. (Figure 1)

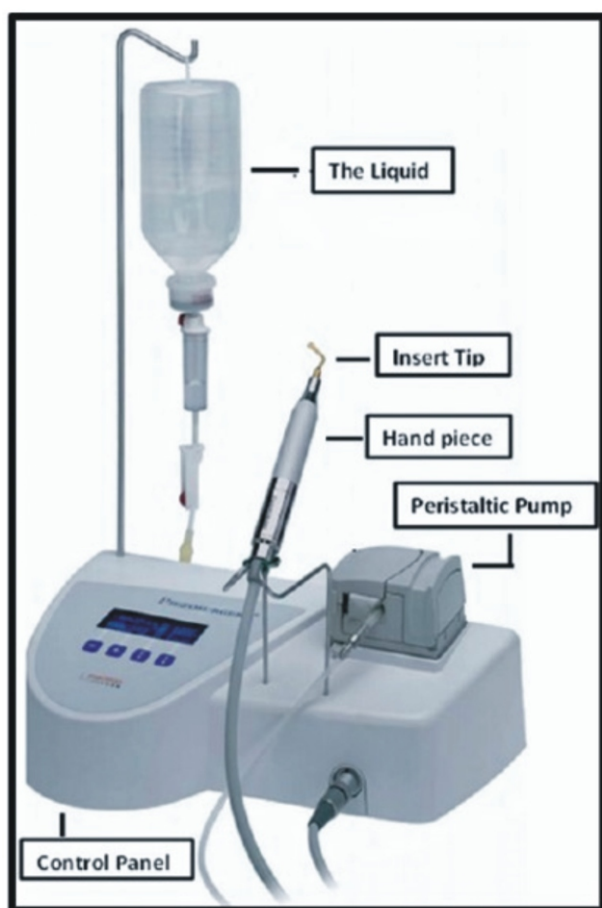


Figure 1: Piezosurgery Unit

#### Main Body

It has a display, an electronic touch pad, a peristaltic pump, one stand for the handle and another to hold the bag containing irrigation fluid. It has two operating modes, 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)<sup>3</sup>

**Bone Mode-** The vibrations generated by selecting bone mode are characterized as extremely high ultrasonic power compared to root mode.<sup>3</sup> Several sophisticated software and hardware controls monitor the performance. Frequency over modulation gives the ultrasonic mechanical vibrations its unique nature for cutting different kinds of bone.

**The selection recommended is: -**

- **Quality 1:** for cutting the cortical bone or high-density spongy bone.
- **Quality 3:** for cutting low density spongy bone.

**Root Mode** The vibrations generated by selecting root mode are characterized by average ultrasonic power without frequency over modulation. Root operating mode consists of two different programs:

**i. NDO Program:** A limited level of power provided by applying reduced electrical tension to the transducer, generates inset oscillation by a few microns which is optimal for washing out the apical part of the root canal in endodontic surgery.

**ii. ERIO Program:** An intermediate level of power between the endo program and the bone program. The ultrasonic wave is transmitted through the transducer in continuous sinusoidal manner characterized by a frequency equal to the resonance frequency of the insert used.

#### Dynamometric Wrench

It is used to tighten the insert tips to the hand piece which applies a predefined force to obtain energy transmission.

#### Handpiece

Each piezo surgery unit comes with two handpieces and is permanently connected to handpiece cord which can be sterilized together.

#### The Peristaltic Pump

It is a part which consists of irrigating solution discharging from the insert with an adjustable flow of 0-60 ml /minute the solution is refrigerated at 4°C for cooling effect. The power of device is 5W[ultrasonic scaler 2W].<sup>6</sup>

#### Insert Tips

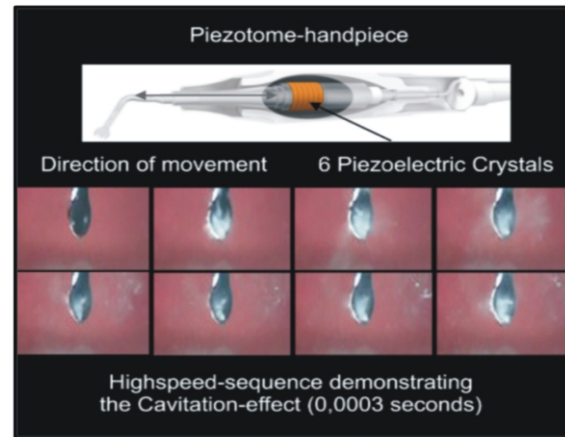
The design and features of all insert tips used in Piezoelectric Bone Surgery have been developed by the Mectron Medical Technology. The inserts have been defined and organized according to a dual classification system, taking into consideration morphological-functional and clinical factors. This system helps understand the cutting characteristics and clinical instructions for each insert. (Figure 2). Various insert tips have been summarized in Table 1.

<b>BASE UNIT /MAIN UNIT ROOT MODE</b>	<ol style="list-style-type: none"> <li>1. Feature mode                         <ol style="list-style-type: none"> <li>i). Root mode</li> <li>ii) Bone mode</li> </ol> </li> <li>2. Specific program                         <ol style="list-style-type: none"> <li>i) Perio Program</li> <li>ii) Bone Mode</li> <li>iii) Special Program</li> </ol> </li> <li>3. Flow of the fluid from cooling system</li> </ol>
<b>INSERT TIPS</b>	
<b>BASED ON MORPHOLOGY/FUNCTION</b>	<ol style="list-style-type: none"> <li>1. Sharp insert tips - for osteotomy and osteoplasty where fine and well-defined cutting of bone is required.</li> <li>2. Smoothing insert tips - for precise and controlled cutting effect during osteotomy.</li> <li>3. Blunt insert tips- to prepare the soft tissues. In periodontics these insert tips are used for root planing.</li> </ol>
<b>BASED ON COLOUR</b>	<ul style="list-style-type: none"> <li>➤ Gold tips                             <ul style="list-style-type: none"> <li>• Used to treat bone.</li> <li>• titanium nitride coatings to improve surface hardness and also for longer working life.</li> </ul> </li> <li>➤ Steel tips                             <ul style="list-style-type: none"> <li>• Used to treat soft tissues or delicate structures.</li> </ul> </li> </ul>

**Table 1: Piezoelectric Device Parts**

### Principle of Piezosurgery

It works on the principle of pressure electrification according to which piezoelectricity is found in certain crystals like quartz, Rochelle salt and ceramics which when subjected to electric charges, acquire electric polarization, expand and contract alternatively to produce ultrasonic waves. Since ultrasonic waves are mechanical in nature, they can induce disorganization and fragmentation of different bodies. The ultrasonic waves also allow segmentation of interfaces from solid –solid by means of distinct vibrations and solid-liquid by means of cavitation( micro boiling phenomenon that occurs in liquids on any solid-liquid interface vibrating to an intermediate frequency, corresponding to a rupture of molecular cohesion in liquids and the appearance of zones of depression that fill up vapor until they form bubbles that are about to implode). When the water spray contacts the insert vibrating to intermediate frequency ;cavitation occurs. The cavitation effect also shows an anti-bacterial property by fragmenting bacterial cell wall, which helps in obtaining high predictability and low morbidity in bone surgery. (Figure 2)



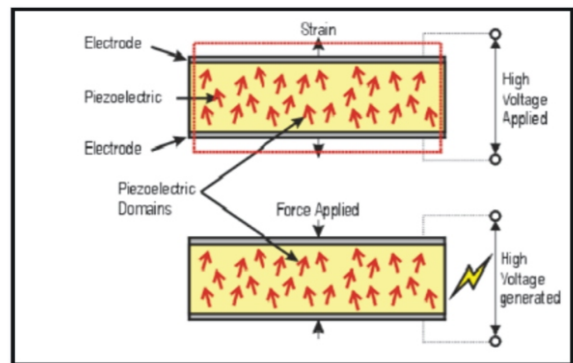
**Figure 2: The hydrodynamic cavitation-effect**

### Mechanism of Action

Ultrasonic is a branch of acoustic dealing with sound vibration in a frequency that ranges above the audible level i.e., >20KHZ where sonic is an ultrasound wave of high amplitude produced by three different methods.

- Mechanical method-upto100KHz**
- Magnetostatic method-18-25 KHz**
- Piezoelectric effect-25-50KHz**

In piezoelectric device the frequency is created by driving an electric current from a generator over piezoceramic rings, which leads to their deformation .the ultrasonic frequency usually ranges from 24-36KHZ, capable of cutting mineralized tissue in dental applications. Thus the accruing movement from the deformation of ring sets up a vibration in the transducer, which creates the ultrasound output. These waves are transmitted to hand piece tip, also called an insert where longitudinal movement occurs resulting in the cutting of osseous tissue by microscopic shattering of bone .The transducer is a very important part of the instrument system because it incorporates a piezoelectric element ,which convert electric signals into mechanical vibrations and finally mechanical vibrations into mechanical energy. (Figure 3)



**Figure 3: Mechanism of Piezoelectric Device**

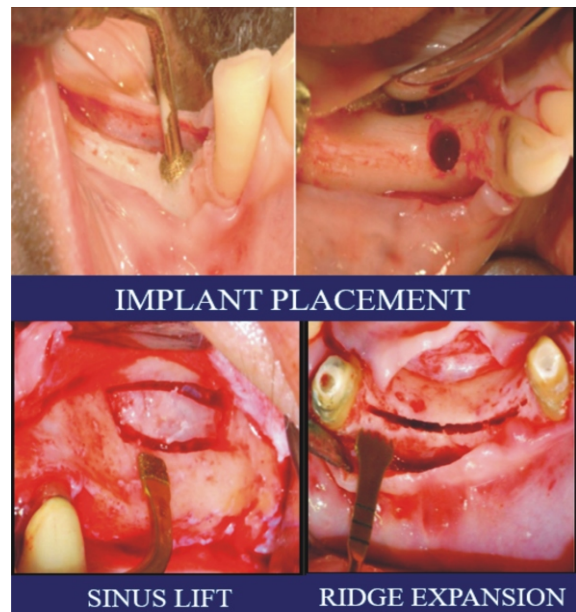
### Applications of Peizosurgery In Periodontics

- ☆ **Scaling and root planing:** The piezosurgery device with a vibrating tip is employed for removal of supra and subgingival debris, calculus and stains from teeth. The piezosurgery ultrasonic scaler set on function on/Mode Periodontics (ROOT), with the insert PS1 and PP1, applied at a medium power of two for 15 sec is used on all the surfaces for removal of deposits.
- ☆ **Curettage:** Piezosurgery device because of its thin tapered tips and altered power setting is used for the efficient removal of diseased soft tissue and root calculus along with the debridement of epithelial lining of pocket wall resulting in micro cauterization.
- ☆ **Clinical crown lengthening:** Piezosurgery is used for precise cutting of hard tissues while preserving root surface integrity .It involves performing a periradicular ostectomy of a few millimeters, which allows repositioning of the periodontal flap in a more apical position.
- ☆ **Resective Surgery:** In interproximal bone defects, diamond coated insert enables thorough cleaning of the bone defects by producing an ultrasonic wave at the base of the defect to aid in better healing.
- ☆ **Periodontally accelerated orthodontics:** Piezo-electric device is used to perform corticotomy by making small vertical incisions between the teeth which allows more expedient orthodontic movement thus considerable reduction in treatment time .<sup>10</sup>
- ☆ **Block Harvesting Technique:** Piezosurgery provides high precision, operating sensitivity and easy differentiation between cortical and cancellous bone while removing blocks of monocortical cancellous bone in bone block harvesting technique.<sup>11</sup>
- ☆ **Osteoplasty and bone grafting:** Piezoelectric devices can be used for grafting infrasonic defects.<sup>12</sup> The device enables gentle scrubbing of the bone surface to obtain sufficient quantities of graft material. The function of the obtained bony chips vary with size (i) Small sized chips aid in early remodelling and (ii) Larger particles provide mechanical support and act as scaffold for bone formation.

### Application In Implantology

The peizosurgery is a new and modern technique in bone surgery in implantology. Implantology offers a variety of techniques to increase bone volume,<sup>13,14</sup> including transplantation of particles and blocks of bone grafts from the chin and the mandibular ramus, iliac crest, and calvaria.<sup>15,16</sup> The techniques make use of rotary drills; oscillating saws; and more recently, piezosurgery, a process that uses ultrasonic vibrations in the application of cutting bone tissue.

- ✘ **Implant Site Preparation:** Piezosurgery used to prepare osteotomy site in the bone and for insertion of implant. Special piezo surgery inserts developed for bone perforation have enabled the development of a new technique for ultrasonic implant site preparation (UISP),which facilitate differential preparation of the cortical and cancellous bone. The differential implant site preparation (DISP) technique can be used within the initial osteotomy site to correct the implant axis by selectively directing the cutting action in the desired direction.<sup>17</sup>
- ✘ **Ridge expansion:** Piezosurgery is an indispensable tool used to create a horizontal osteotomy through the alveolar bone crest caused by its precise (narrow) cutting action. In some cases (e.g., areas of dense bone with little elasticity), it may also be necessary to make one or two vertical cuts in the alveolar bone to allow ridge expansion.<sup>18</sup> .
- ✘ **Sinus lift or augmentation:** Sinus augmentation is performed in following situations; pneumatised sinus, atrophy of alveolar ridge, and poor bone quality especially in the posterior maxilla. The surgical technique performance depends on the remaining bone between the alveolar crest and the floor of the maxillary sinus. Using piezoelectric ultrasonic vibration range between 25-30 kHz, the device cuts only mineralized structures without cutting the soft tissue. The cavitation effect of the system induces a hydropneumatics pressure of saline irrigant that contributes to the atraumatic elevation of the sinus membrane as perforation of schneiderian membrane resulting in poor graft stabilization, sinus infection, epistaxis and extensive bleeding. (figure4)<sup>19</sup>



## Advantages

### Piezosurgery offers the following characteristics:

- **Micrometric:** the inserts vibrates with the range of 60-200 micrometer thus avoiding excessive temperatures.
- **Selective:** the vibration frequency is optimal for the mineralized tissue.
- **Safe:** using of a modulated ultrasonic frequency allows a highly precise and safe cutting of hard tissues whereas adjacent soft tissue and nerve remain unharmed making it superior compared to conventional rotating instrument.<sup>5</sup>
- **Precision:** the accuracy and selectivity of pesosurgery is superior to conventional rotating instruments. with pesosurgery we can osteotomize hard tissue as precisely as possible.
- **Surgical control:** pesosurgery provides surgical control with maximum strength required by the surgeon to effect a cut is far less compared to that with the drill or with oscillating saws
- **Cavitation effect:** created by interaction between the irrigant solution and the oscillating tips makes the surgical site clear during osteotomy.

### Limitation:

- Increase in operative time compared to traditional cutting instrument.
- Gentle touch and dexterity is required for this type of procedure with a different learning curve.
- In deeper osteotomies it's difficult to insert proper length and thickness to avoid the increasing pressure of the hand preventing microvibration of the insert.
- Not cost effective
- Inserts get warm very rapidly.
- Increase operative time compared to traditionally cutting instrument.

### Conclusion

By using technique of piezoelectric ultrasonic vibrations the critical operations can be done in simpler and safer way with less post-operative complications. This technique can be used in oral surgical procedures to have better results. It aids in bone healing minimal intra-operative bleeding etc. The piezosurgery units because of its variable frequency and variable power are used for range of application in periodontology implantology etc. making it highly efficacious tool in clinical practice.

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