

# Piezoelectric Surgery: A Predictable and Painless Approach in Periodontics

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**Abstract:-** Dentistry, is an art in science and tranquilizer in medicine, has seen many challenging surgeries. Procedures over years. In starting it began with using the traditional tools. To overcome the disadvantage of the traditional tools, nowadays new device has been in rule such as, Piezosurgical device. It is one of the best innovations in the modern dentistry, in periodontics it is used in various applications such as bone grafting, curettage, crown lengthening, Ridge expansion, and in many departments such as implantology, conservative dentistry, oral and maxillofacial surgery. It leads to the safe and precise bone incision without damaging the associated structures. It creates the bloodless field during the surgical procedures. In osteotomy and osteoplasty, it is widely in use. Healing process in piezosurgery is very shorter. It is safe to use for surgeons and also creates the comfort zone to the patient. It is three times more powerful than the conventional ultrasonic units. The piezosurgical device consists of a novel piezoelectric ultrasonic transducer powered by an ultrasonic generator capable of driving a range of resonant cutting inserts. Piezosurgery can be defined as a saw characterized by the versatility particularly in perform osteoplasty and Osteotomies. This article aims to review piezoelectric surgery and its role in periodontics, it's mechanism, equipment, applications, osteotomy and osteoplasty tips finally advantages and disadvantages.

**Keywords:-** Piezosurgery, Osteotomy, Osteoplasty.

## I. INTRODUCTION:

Over the last few decennary, there has been expeditious development in dental surgical techniques, simultaneously, by using hand instruments and rotary instruments **osseous surgery** was performed. By using these kinds of burs, it requires external copious irrigation because of the heat production by these instruments. In addition to this pressure was also exerted in osseous surgeries. Fractures and brittle bone also accompany with the pressure in osseous surgeries. To overcome these pressure and limitations, a novel surgical technique was introduced term **PIEZOSURGERY**, to reduce the injury occurring in surrounding tissues. Piezosurgery was invented by professor VERCELLOTTI in 1988<sup>[1]</sup>

It is a technique of bone surgery which is gaining a major success in the dental field. It is used in the branch of osteotomies, implantology, periodontology and many oral surgical procedures<sup>[2]</sup>

piezosurgery plays a major role in bone surgeries and it fulfils the biological and technical criteria. Piezo surgery is a safe method to use it does not damage the supporting and vital structures such as nerves, mucosa and vessels, because it uses a low micro vibrations which range from **60-200 micro/sec**, through internal irrigation mechanism it removes debris, simultaneously it overcomes some difficulties such as visibility by producing bloodless field during surgical procedures<sup>[3]</sup>

Nowadays piezo surgery 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<sup>[4]</sup>

Piezosurgery is also called as piezo electric surgery. Piezosurgery device is commonly an ultrasound machine with a correct modulated frequency and controlled tip with vibration range<sup>[5]</sup>

In this piezo surgery, the piezoelectric effect occurs when the current is passed around a stack of crystals and then it starts to vibrate at a moderate frequency. This piezoelectric instrument produces an ultrasonic frequency which ranges from **24 to 29KHZ**<sup>[6]</sup>

The cutting characteristics of the piezosurgery mainly depends on the pressure given, degree of mineralization, design of insert being used and speed usage<sup>[7]</sup>

## II. MECHANISM OF ACTION:

“**piezo**” in Greek term “piezein” meaning pressure in, which denotes that piezoelectric device works on the principle of” pressure electrification “that defines when electric tension is applied across certain materials, the material expands and contracts by producing ultrasonic vibrations<sup>[5]</sup>The materials that helps in performing these actions are Rochelle salts, quartz, and certain types of ceramic<sup>[8]</sup>

The working mechanism of piezo includes it converts mechanical energy in the form of tension and compression into electric energy.

Piezoelectric surgery provides certain features such as cavitation, heat, formation of bubbles, ultra-massage, electric and acceleration.<sup>[7]</sup> The frequency of piezoelectric unit in which it is operated is 25-50khz.The ultrasonic waves can allow segmentation of interfaces from solid to solid by means of distinct vibration and solid -liquid by means of cavitation.

Piezoelectric ultrasonic frequency is created by compelling an electric current from a generator over piezo-ceramic tings that leads to their deformation<sup>[9]</sup>

The term cavitation describes the process of vaporization, bubble formation and subsequent implosion into many fractions of its original size that occurs due to decrease and increase in pressure as result of ultrasonic vibration.<sup>[3]</sup>

As the cavitation effect is attributed with anti-bacterial efficiency, it fragments cell wall of bacteria. Thus, these phenomenon helps in ultrasonic osteotomy by dispersing coolantfluid which causes the blood to be washed away thereby maintaining good visibility in operating field<sup>[10]</sup>

The different vibrating frequency of device is targeted for different action, the frequency of 25 to 29 khz can be modulated with low frequency of 10hz to 70 hz and high frequency upto 30khz.Frequency <30 khz is targeted to cut only mineralized tissue, and frequency more than 50 khz is for cutting neurovascular and other soft tissues \Precision cutcan be achieved with minimal pressure when using piezoelectric surgery in contrast to conventional micro-saws where high degree of pressure is required<sup>[11]</sup>

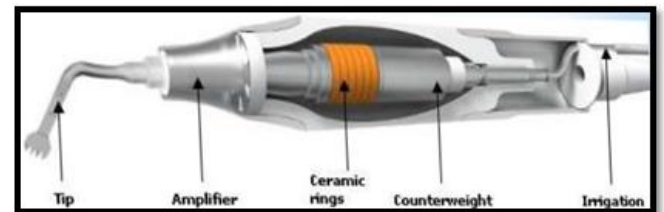


Fig 1:- Piezoelectric Instrument Design

### ➤ *Equipment:*

The first model of piezoelectric device was introduced by Vercellotti et al<sup>[3]</sup> The principle of the device is that crystalline structure like quartz tends to change in shape when subjected to electric field, as the operating unit of piezoelectric device is between 25-50khz, crystals enclosed in handpiece produces dimensional changes through passage of electricity over the surface of crystals, producing osseous repair and remodeling when compared to carbide and diamond burs<sup>[2]</sup>

The major characteristics that are essential for operating piezoelectric device is based on density of bone, design of insert, pressure of handpiece, speed of movement and in addition to these, three adjustable settings frequency of ultrasonic vibration, level of power, water spray is considered<sup>[7]</sup>

### ➤ *BONE MINERALISATION (Density):*

The cutting efficiency of device is interrelated to level of Mineralization of bone, higher the Mineralization of bone higher the setting range if frequency and vice versa in case of low mineralized bone. Frequency range for high frequency is 30hz for cutting bone. Alternative pauses are provided for optimal cutting and prevention of lodges in bone<sup>[7]</sup>

### ➤ *Insert Design:*

Different types of design and shapes that are Applicable for different procedure is tightened with the handpiece e.g. Saw-shaped insert<sup>[3]</sup>

### ➤ *Pressure:*

Pressure exhibited by handpiece is related to bone temperature, inserts should be moved with backwards and forward at a high speed with minimum pressure, Depth of about 150gms of load is essential for achieving maximum depth, Excessive pressure decreases oscillation and hence the cutting ability<sup>[3]</sup>

➤ *Speed:*

The tip of device is operated at controlled speed of 60-200mm/sec<sup>[14]</sup>. Decreased degree of speed is operated for effective cutting. Speed and irrigation system are controlled with + or - button on the control panel<sup>[3]</sup>

**III. PARTS OF THE INSTRUMENT:**

The device unit is composed of main body and holder for handpiece, inserts and irrigating coolant fluids

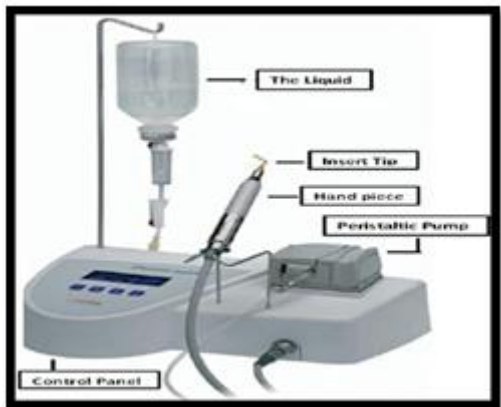


Fig 2:- Piezosurgery Unit

➤ *Main Body:*

The main body can be operated in various modes like root and bone modes with the electronic display.

➤ *Root Mode:*

In the root mode, the power can be opted between endo or perio modes<sup>[1]</sup> The vibration generated by selecting root mode are characterized by average ultrasonic power without frequency over modulation<sup>[11]</sup>

➤ *Endo Mode:*

In this mode, transducer produces limited level of power as the electric tension applied is reduced, generating insert oscillation by few microns<sup>[5]</sup>. These mechanical micro vibrations are efficient in washing out the apical part of root canal<sup>[11]</sup>

➤ *Perio Mode:*

This is the intermediate level between endo and bone mode. The ultrasonic wave is transmitted through the transducer in continuous sinusoidal manner characterized by a frequency equal to the resonance frequency of insert used<sup>[5]</sup>

➤ *Bone Mode:*

The vibration generated by selecting bone mode are extremely high ultrasonic power than root mode<sup>[11]</sup> Based on type of bone to be reduced, Quality 1 for cutting cortical bone or high-density spongy bone. Quality 2 for cutting low density spongy bone<sup>[5]</sup>

➤ *Handle:*

The ultrasonic waves generated by piezoceramic disks determines cutting actions<sup>[3]</sup>. Handpiece is provided with

holder and irrigating fluids of jet 0-60ml /min through peristaltic pump for cooling and removal of debris.<sup>[2]</sup>

➤ *Inserts:*

The design and feature of inserts are developed by Mectron Medical technology for different surgical needs<sup>[11]</sup>

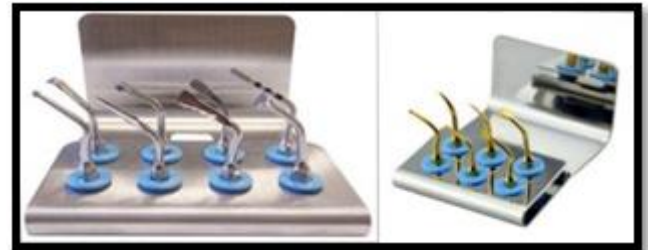


Fig 3: Insert Tips

Inserts are classified as titanium nitrate coating, diamond coating,

➤ *Titanium Nitrate Coating:*

It is used in case of osteoplasty technique or for harvesting bone chip. It is also advantageous because of its cutting efficiency, Increased working life, Non-corrosive property<sup>[1]</sup>

➤ *Diamond Coating:*

These tips are very useful for operating near anatomic structure because it provides clinically less efficacious cut, and safer near such structures<sup>[1]</sup>

Classified as **sharp insert tips, smooth insert tips, blunt insert tips.**

They are useful in procedure like thin bone osteotomy or osteoplasty, preparing sinus window, elevating Schneider membrane or lateralizing the nerve and root planning in periodontics.

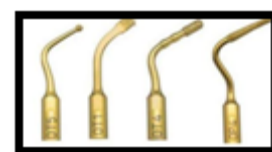


Fig 4: Smooth Tips



Fig 5: Sharp Tips



Fig 6: Blunt Tips

➤ *Irrigation:*

The irrigating coolant fluids provided water spray removes debris and contributes blood free surgical area and offers great visibility in Operating field because of cavitation effect if irrigation<sup>[3]</sup>

#### IV. APPLICATION OF PIEZOSURGERY IN PERIODONTICS:

In periodontics piezo surgery is basically used in scaling procedures. It is also used for surgical procedures in periodontics such as osteotomy, osteoplasty, lengthening of crown, resective surgery and regenerative surgery<sup>[3]</sup>

Piezosurgery also used in bone harvesting procedures. In other devices, rotating saws will cause damage to the adjacent tissue structures and damage soft tissues such as tongue and cheek and the incisions is more difficult in that devices, whereas the piezosurgical devices is less sensitive in nature and it does not produce damage to the adjacent tissue structures and soft tissues. The horizontal and vertical incision is made without damaging the tissues and it creates a comfort zone to the patient. After the incision process in piezo device it is used to remove the secondary flap. In the result of micro cauterization this device is used for debriding the epithelial lining of the pocket wall. Piezosurgery is also used in sinus grafting procedures<sup>[11]</sup> By using the piezosurgical device, it causes minimal or no trauma from adjacent structures while doing autogenous bone graft procedures<sup>[12]</sup>

➤ *Sinus Elevation:*

Perforation of membrane and surgical trauma will cause while doing sinus elevation procedures with normal burs. So piezosurgical device is very much useful in such cases because it inserts a bur which is blunt tip, it is useful in atraumatic elevation procedures such as grafting procedures.<sup>[3]</sup>

➤ *Scaling And Root Planing:*

Cavitation removal is the process by which some energy is required for the removal of deposits present in the teeth. And there is a MYTH believed that to remove the calculus there has to be contact between vibrating tip and calculus is necessary, therefore, it is now accepted that the mechanical energy produced by the vibrating tip in the device along with the cavity is required for the deposit removal. The piezosurgery ultrasonic scalar set is used in the deposit removal process. Compared to the conventional scalar set piezosurgical scalar set is believed to produces no or less damage to the root surface<sup>[13]</sup>

➤ *Curettage:*

In the process of microcauterization, for debriding pocket wall lining piezosurgical device is very much useful and in cases of crown lengthening process in which bone is to be reduced, according to the patient's convenient structure to preserve a root integrity this device helps in reducing into acquired size<sup>[1]</sup>

➤ *Resective Surgery:*

The use of piezosurgery in periodontal surgery is very much useful compared to the other devices because it is easy to handle and handling of the device is very much convenient. After raising the primary flap in the resective surgery this device makes it easier to accompany with the secondary flap and removing the inflammatory granulation tissue, this phase will cause a light bleeding but by using a correct ultrasound vibration it doesn't cause bleeding. Even in an interproximal bone defects, with the help of the special diamond coated but it cleans very deeply. Healing is improved very much by producing an ultrasound to provide a micropits at a base of the defect to produce a healing mechanism<sup>[13]</sup>

➤ *Ridge Expansion Procedure:*

For increasing the bone width and placing the implants in the narrow ridges, the horizontal alveolar ridge expansion is a useful procedure. For this piezosurgery is a vital key and useful device. Thus, playing a major role in this procedure. It creates a precise cutting action in it. In piezosurgical device it has a screw or fan type expanders for increasing the diameter so it helps to expand the area in horizontal osteotomy procedure<sup>[13]</sup>

➤ *Bone Grafting:*

There are different types of ridge augmentation procedures and a sufficient measure for this generation. Bone grafts result in a greater short-term cell viability and it shows a new bone deposition and remodeling of the bone by using the piezosurgery device. So, it is termed to be efficient measure for bone grafting procedure. By comparing the piezo surgical device and conventional. Piezo electric device shows a greater convenience because it is easy in precise cutting, especially in bone grafting techniques. Piezosurgical device will undergo the surgeries and remove grafts which is difficult to undergo surgery by many devices. In cases such as, lateral wall of the maxillary sinus. So, it is ease to handle piezosurgical device<sup>[4]</sup>

➤ *Nerve Lateralisation Procedure:*

Piezosurgery device is used in nerve lateralization or transposition procedure. This device has a precise cutting efficiency so it is important in this procedure because, it involves a surgery which is indicated in nerves such as inferior alveolar nerve. In nerve regions an accurate instrument only needed. so, piezo device is used nowadays. The piezosurgical device is invasive but very much safe compared to other devices<sup>[1]</sup>

➤ *Implant Site Preparation:*

Piezosurgical device is efficient in the implant site osteotomies because it only has a precise cutting efficiency and microstreaming property. Because, it preserves a soft tissue. This device plays a major role in the esthetic and healing properties. While using the piezosurgical device healing in implant site preparation will be done within two to eight weeks compared to the usage of other devices. This device is very much effective compared with other device because it stimulates the osteogenesis of implant, producing osteoblastic activity around the implant sites. During the



osseointegration process, this piezosurgical device produce a potential to modify the biological events <sup>[1]</sup>

➤ *Peri-Mucositis And Peri-Implantitis:*

This device is used in the treatment of peri mucositis and peri implantitis procedures. After the incision of retained periosteum this device is used for the soft tissue debridement to remove the secondary flap <sup>[1]</sup>

Apart from periodontics piezosurgery is very much useful in endodontics and oral and maxillofacial surgery.

➤ *Advantage;*

The main advantage of the piezosurgery is, it provides a supportive agent to the adjacent structures and it also reduces a thermal damage to the bony surface whereas other devices will cause a major defect. In this procedure healing occurs rapidly because it does not produce any damage to the osteocytes. The design of the device is used in the areas where it is difficult to access. In first phase of bone healing it becomes more efficient. Due to the reduced damage to associated structures, it controls the inflammatory process better than other devices. It is better than conventional therapy because remodeling occurs very much easy as 56 days after the treatment <sup>[14]</sup>

In piezosurgery, hand pressure is less needed, easy to access the indirect vision, and control is very much easier. During nerve lateralization procedures it causes less damage to blood vessels or no damage at all <sup>[15]</sup>

It does not cause an emphysema risk during the surgical procedures. Due to less hand pressure needed, the control of the device is very much supportive during surgeries, therefore the patient stress level will be reduced. Compared to other devices it provides a blood free field <sup>[5]</sup>

It contains a sterile coolant which provides a contamination free zone. The major advantage of the surgery is, a good cutting action in a device thus it provides a good healing to the tissues <sup>[8]</sup>

while undergoing an osteotomy procedure piezosurgical device is the best device because it provides good visibility to access. Due to its less invasive procedure it provides a reduced post intervention pain. Compared to other devices this device produces a less sound and it produces only micro vibrations during surgeries. This piezosurgical device provides a highest efficiency when applying a load of 0.5 kg. This device is three times more powerful than the other devices. Due to this advantage of piezosurgery the psychological fear and stress is reduced to the patients <sup>[13]</sup>

➤ *Disadvantage;*

The main disadvantage of the piezoelectric device is its increase in operating time when compared with the other traditional cutting instruments. This device is not used in the pacemaker patients. In the deeper osteotome procedures it is difficult with the piezosurgery device, as the increasing pressure while doing the procedure this pressure turns into heat. So, it is the major drawback in this device. By the

uncontrollable heat produced by this instrument it will break or damage the tissue structures <sup>[13]</sup>

With the piezosurgical device, the technique is difficult to adapt and learn. It is difficult in practical purposes. The operating time needed for bone preparation is increased so it will cause the pressure on patients <sup>[12]</sup>

The cutting depth is low and precision is caused due to the vibrations. Intraoperative sensitivity will be caused <sup>[15]</sup>

It is unable to reach all the areas while doing a surgical procedure. In some surgeries the additional instruments are needed apart from the piezosurgical device. It causes thermal damage to the target tissues. In the applications of piezosurgery the duration is very much higher than the other devices in some surgeries. More practice time with this device is needed for the clinicians <sup>[14]</sup>

Tip breakage will happen many times so stocking the tips is very much essential in this device. In some cases the device will be slow. Cutting the dense bone will take up to four times longer than with the other burs. Due to its thermal production the use of irrigation is very much essential to avoid the thermal production <sup>[2]</sup>

The gentle touch and correct dexterity are needed with a different learning curve for this piezosurgical device. This device is not used in the patients with cardiopathy, metallic crowns and uncontrolled diabetes mellitus <sup>[1]</sup>

## V. OSTECTOMY AND OSEOPLASTY TIPS:

By using this piezosurgical device, osteoplasty and ostectomy can be done which is used in creating positive architecture for the pocket elimination surgery. This device is used for the easy removal of bone, with no or minimal risk to the underlying root surfaces and associated structures. Final step is smoothing of the root surface, it is done using this piezosurgical device and bony margins is done using this device with accurate ultrasonic insert, clean field is done with the ideal bony architecture which is ready for flap closure <sup>[9]</sup>

By using the **SHARP INSERT TIPS** in the piezo device, the ostectomy and osteoplasty can be done in cases such as where fine and well-defined cutting of the bone is required. For precise and controlled cutting effect during the ostectomy procedure, the **SMOOTHING INSERT TIPS** is used. According to the basic surgical technique like ostectomy and osteoplasty the clinical classification includes the inserts such as sharp and smoothing tips. In ostectomy (OT)-**OT1-OT2-OT3-OT4-OT5-OT6-OT7-OT74-OT7S3-OT8R/L** is used and in osteoplasty (OP)-**OP1-OP2-OP3-OP4-OP5-OP6-OP7** is used. The inserts used in the techniques of ostectomy and osteoplasty is used in the combination with each other for different surgical protocol. Piezoelectrical devices is a safe and protective method in the techniques such as ostectomy and osteoplasty compared with the other methods which uses a rotating instrument because of the absence of macro vibrations <sup>[14]</sup> Nowadays

piezosurgical device is used widely in the osteoplasty and ostectomy procedures. The morphological characteristics of the ostectomy and osteoplasty is mainly depending on the tips and unit used in that procedure.<sup>[4]</sup>



Fig 7:- Osteotomy Insert Tips

## VI. DISCUSSION:

Piezosurgery is considered to be a great and safety method in the bone surgery compared to the manual and motorized instruments. Piezosurgery device allows precise cuts during osteotomy procedure. Piezosurgery device gives the best result in the bone healing process. Piezosurgical device helps in the bone saving in osteotomy sites. By using this device, blood loss during the surgeries can be reduced by 25-30% due to the best visibility. The micrometric vibration of tips is highly useful in the osteotomy procedures<sup>[16]</sup>

Piezosurgery reduces edema, pain, ecchymosis and Haemorrhage after the surgery and it increases the satisfaction of the patient. Piezosurgery does not cause soft tissue injury. In postoperative period it was accompanied with the less hemorrhage and ecchymosis<sup>[17]</sup>

This technology counts on the irrigating system coped with the handpiece, it prevents the borders of the osteotomy. This, avoiding the periodontal injuries on the tissues. During the osteotomy procedures it has a low rate of bleeding. The contraindications of the device are pacemaker patients and age factor to be considered. And, cost is more by using this device. In piezosurgical device bone grafting, ostectomy and osteoplasty are performed<sup>[18]</sup>

The use of the piezosurgical device is considered to be provide a success rate to the patient and it gives a great advantage to the dentist. It gives the comfort zone to the patient. The major criticism of this is higher time consumption<sup>[19]</sup> The use of chisel, hammers will cause the pain in some surgeries for patients, so stress level will be increased for some patients. To overcome this problem, piezosurgical device is widely used nowadays<sup>[20]</sup>

In this piezosurgical device, the sensitive procedures such as sinus floor elevations, nerve transpositioning is much easier. This device gives best results in the bone morphogenetic proteins, controls the inflammatory process better, stimulates the remodeling of bone as early as 56 days after treatment<sup>[11]</sup>

## VII. CONCLUSION:

Piezosurgical device is a safe, effective and precise to work on the tissues of bone. It is easy to handle by the clinicians and due to the less damage to the associated structure it gives comfort zone to the patient. In surgical field it gives better visualization. Soft tissues were protected using this piezosurgical device. The success rate in surgeries is high using this device, as well as the prevention average of the post operator complications, without the increase of the trans operator surgery time.

Ostectomies and osteoplasties can be done without much difficulties using this piezo device. Although there is a great deal in the scientific research focuses on new products for tissue engineering and bone regeneration. The importance of the minimal surgical trauma for bone healing is difficulty now a days. Piezosurgery is an innovative ultrasonic technique which is much effective compared with the other soft tissue methods and traditional hard tissue methods that use rotating instruments because of the absence of macro vibrations. Piezosurgical device has the physical and mechanical properties such as sparing of vital, neurovascular bundles and so, this device and this procedure used by this device should be considered in the everyday life.

Piezosurgery ensures three P's in it they are, **PREDICTABILITY, LESS POSTOPERATIVE PAIN, AND INCREASED PATIENTS COMPLIANCE.** Piezosurgical device is much effective in operative sensitive cases. In periodontics this device is used in various techniques such as, scaling and root planning, sinus elevation, Bone Grafting, Ridge Expansion procedure, Nerve Laterization procedure, resective surgery, etc. Apart from periodontics, this piezosurgical device is used in various platforms such as oral medicine, oral and maxillofacial surgery, conservative dentistry and prosthodontics.

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