

Piezosurgery: A Boon For Modern Periodontics – A Review

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ABSTRACT

Dentistry has undergone significant advancement and has several changing concept over a decade. One such innovation is piezosurgery. Piezosurgery was originally developed for the atraumatic cutting of bone by way of ultrasonic vibrations and as alternative to the mechanical and electrical instruments that are used in conventional surgery. It is based on the basic principles of 'piezoelectricity' discovered by Pierre Curie and Jacquesin 19th century. So this review discusses the equipment, mechanism of action, biological effects on bone, indications, contraindications, advantages and disadvantages of this new technology.

KEYWORDS: *Cavitation, implants, osteotomies, piezosurgery, ultrasound*

INTRODUCTION

Over the past few years dentistry has seen a lot of innovations. Recent advances include latest diagnostic imaging techniques like ultrasonography, cone beam computed tomography and procedures like microsurgery, implants, lasers and nanotechnology. Ultrasonic vibrations have been used to cut tissues.⁽¹⁾ These innovations is one of the forerunners in medical fraternity. One such novel innovation is piezosurgery which was invented by TomasoVercellotti and it was developed by Mectron Medical Technology. Piezosurgery is a true revolution in the field of periodontology and implantology.⁽²⁾ Piezosurgery uses piezoelectric ultrasonic vibrations to perform precise and safe osteotomies.⁽³⁾ It reduces damage to osteocytes and permits good survival of bony cells during harvesting of bone.⁽⁴⁾ 'Piezo' is derived from Greek word 'piezen' meaning pressure. Piezosurgery works on principle of 'pressure electrification' according to which piezoelectricity is found in certain crystals like quartz, Rochelle salt and ceramics. When subjected to electric charges, it 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 allows segmentation of interfaces from solid-solid by means of distinct vibration, and solid-liquid by means of cavitation.⁽⁵⁾ Piezosurgery device (sophisticated ultrasonic device) which can be used in a variety of dental surgical procedures like periodontal surgery, periapical surgery, removal of impacted teeth, in implant surgery for facilitating bone ridge expansion, in bone regeneration techniques and inferior dental nerve lateralization and transpositioning. Piezoelectric device is used to cut or grind the bone without damaging the adjacent soft tissues. The mechanism of this instrument is mainly based by the 'piezoeffect'.⁽⁶⁾

Background And History

Piezoelectric effect was first described by French Physicist Jacques and Pierre Curie in 1880. In 1953, within the field of dentistry, ultrasonics established itself mainly in periodontology, and endodontics when Catuna first reported cutting effects of high frequency sound waves on the dental hard tissues.⁽⁷⁾ Piezosurgery was first introduced by Dr.TomasoVercellotti in 1997 and first developed by Mectron (Italy) Medical technology in 1998.⁽⁵⁾

Piezoelectric Equipment

Piezoelectric devices consist of handpiece and footswitch these are connected to the main power unit. It has a holder for the hand piece and contains irrigation fluids that create an adjustable jet of 0-60ml/min through a peristaltic pump removing debris from the cutting area and maintains a blood free operating area because of cavitation (production of imploding bubbles) of the irrigation solution giving greater visibility particularly in complex anatomical areas by dispersing coolant fluid as an aerosol.⁽⁴⁾⁽⁷⁾

The instantaneous frequency is automatically controlled in response to the pressure load on the tip. The parameters under the control of the operator, apart from the pressure applied, are the pulse frequency (when available), the rate of delivery of coolant, and the applied power, which in some instruments is limited to 3-16W and in others has a maximum of as much as 90W. In most instruments, power is controlled by selecting the type of bone to be cut or the procedure to be performed. The peak to peak amplitude of tip oscillations, typically in the range of 30-200mm in the plane perpendicular to the shaft of the working piece (some instruments also or exclusively oscillate along the shaft), ensures precise micro abrasive incision.⁽⁷⁾

Mechanism Of Action

Ultrasonics is a branch of acoustics dealing with sound vibrations 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 – up to 100 kHz

Magnetostatic method - 18-25 KHz

Piezoelectric effect – 25-50 kHz

In piezosurgery, piezoelectric effect is used where mechanical energy is converted into electric energy in the form of tension and compression. Piezoelectric ultrasonic frequency is created by compelling an electric current from a generator over piezo-ceramic rings, which leads to their deformation. The ultrasonic frequency usually ranges 24–36 kHz, capable of cutting mineralized tissue in dental applications.⁽³⁾ 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 the 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 converts electric signals into mechanical vibrations and finally mechanical vibrations into electric signals.

Cavitation is the microboiling phenomenon occurring in liquids on any solid–liquid interface vibrating to an intermediate frequency, corresponding to a rupture of the molecular cohesion in liquids and the appearance of zones of depression that fill up with vapor until they form bubbles that are about to implode. In case of detartrating tools, cavitation occurs when the water spray contacts the insert vibrating to intermediate frequency.

In ultrasonic osteotomy procedures, this phenomenon maintains good visibility in the field of operation by dispersing coolant as an aerosol and providing hemostasis. The cavitation effect also shows an antibacterial property by fragmenting bacterial cell wall, which helps in obtaining high predictability and low morbidity in bone surgery.⁽⁵⁾

PROPERTIES OF PIEZOELECTRIC DEVICE

1. Micrometric cutting- Due to limited vibration amplitude(max.200µm) and the design of osteotome tips for specific surgical situation, it offers precise bone cutting accompanied by high tactile sensitivity.⁽⁸⁾
2. Selective cutting – Bone cutting without the risk of damaging adjacent soft tissues. The ultrasonic frequencies (25-29kHz) that are used for hard and soft tissues are cut at different frequencies.⁽⁹⁾
3. Bleeding free surgical sites for maximum intraoperative visibility and high predictability. Due to the cavitation effect, bubbles are created from the physiological salt solution that leads to implosion and generate the shock wave causing microcoagulation.⁽¹⁰⁾

Biological Effects On Bone

The effects of mechanical instruments on the structure of bone and the viability of cells are important in regenerative surgery. Relatively high temperatures, applied even for a short time, are dangerous to cells and cause necrosis of tissue. This techniques clinically effective and also histological and his tomorphometric observation of postoperative wound healing and formation of bone in experimental animal models has indicated that the response of tissue is more favorable after piezo surgery than after conventional bone cutting techniques with diamond or carbiderotary instruments.⁽⁸⁾

The result of a histologic comparison of the effect of a standard ultrasonic insert to a rotary bur, and a surgical chisel has shown that the ultrasonic insert, like the surgical chisel, was found to cut and not burnish bone and the rotary bur was observed to produce the smoothest surface of bone, the rate of bone healing proceeded best when the bone was removed by a surgical chisel or ultrasonic insert.⁽¹⁾

The rate of postoperative level of bone change was used to compare the effectiveness of this instrument with a standard carbide bur and a standard diamond bur and the results indicated that PS provided a more favourable osseous response than traditional carbide and diamond burs when surgical osteotomy and osteoplasty procedures were performed.⁽⁵⁾ Because the PS insert vibrated within a width of 60–200 mm at a modulated ultrasonic frequency, an increase

in temperature was avoided that eliminated bone damage. Ultrasonic osteotomy preserves the bone micro-structure which facilitates bone healing and, in turn, osseointegration, which is the key to implants success.⁽¹¹⁾

Indications

(1) Soft tissue debridement, (2) smoothing of root surfaces, (3) bone grafting, (4) implant site preparation, (5) removing an implant, (6) sinus lifting procedure, (7) retrograde root canal preparation, (8) apicectomy, (9) cystectomy, (10) extraction of ankylosed teeth, and (11) orthodontic surgeries.⁽¹²⁾

Contraindications

No absolute contraindications (1) Cardiopathy, (2) patients with uncontrolled diabetes mellitus, (3) patient receiving radiotherapy, (4) patients with metal/ceramic crowns, (5) patients with pacemakers

Applications In Dentistry

Piezoelectrical 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⁽⁵⁾.

Applications In Periodontology

The piezosurgery device with avibrating tip is used for removal of supra and sub gingivaldebris, calculus and stains from teeth. Cavitation effect and micro streaming disrupts the bacterial cell wall. The inserts are placed vertically parallel to the long axis of the tooth and is moved continuously providing better patient comfort and calculus removal. Piezosurgery device can be used for efficient removal of diseased soft tissue and removal of root calculus compared to manual instruments by using thin tapered tips and altered power setting.⁽¹³⁾

It simplifies and improves handling of soft and hard tissues. In resective periodontal surgery, it uses a scaler shaped insert to detach the secondary flap and remove inflammatory granulation tissue. Cavitation of the saline solution (coolant) facilitates effective scaling, debridement, and root planing and bleeding is minimal. Diamond coated insert enables thorough cleaning of the inter proximal bone defects. The mechanical action of ultrasonic microvibrations, together with cavitation of the irrigation fluid (pH neutral; isotonic saline solution) eliminates toxins, bacteria, debris, dead cells and which creates a clean physiology for healing.

The crown lengthening technique performed with piezosurgery using appropriate inserts makes it possible to effectively reduce bone while preserving root surface integrity. The osteotomy is simple to perform using piezo surgery in direct contact with the root surface because control of the instrument during surgery is precise, even in very difficult proximity cases. Root planing can be performed very effectively using blunt ultrasonic inserts.⁽¹⁴⁾

Applications In Implantology

Harvesting block graft Piezosurgery provides high precision and operating sensitivity and easy differentiation between cortical and cancellous bone while removing blocks of monocortical cancellous bone.⁽⁸⁾ Osteotomy procedure where piezosurgery decreases the risk of bone fracture, making bones more elastic after osteotomy with ultrasonic intermediate vibration, thereby minimizing complications. Distraction osteogenesis followed by implant placement, for retrieval of blade implants, in ridge expansion, maxillary sinus elevation, drilling holes in bone for implant placement, for insertion of implant.⁽¹⁵⁾

PROS

1. Piezoelectric bone surgery seems to be more efficient in the first phase of bony healing; it induces an earlier increase in bone morphogenetic proteins, controls the inflammatory process better, and stimulates remodelling of bone as early as 56 days after treatment.⁽¹⁶⁾
2. No risk of emphysema.⁽¹⁷⁾
3. Micrometric cutting action: precise incision with no damage to adjacent structures.
4. Selective cutting action: sectioning does not damage the adjacent soft tissues.
5. Possibility to adapt the frequency of the vibrations of piezoelectric ceramics produces an efficacious and efficient cutting action on the bone of different quality.⁽¹⁸⁾

CONS

1. Increased operating time required for bone preparation
2. The cost of ultrasonic osteotomy equipment is more than mechanical osteotomes⁽¹⁷⁾
3. Longer operating time and increasing working pressure impedes the vibration of device that transforms the vibrational energy into heat, so tissues can be damaged, therefore, the use of irrigation is essential not only for the effect of cavitation but also to avoid overheating.
4. Moreover, the technique is difficult to learn.
5. 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.⁽¹⁹⁾

CONCLUSION

Piezosurgery is a new surgical technique for bone surgery with many clinical applications in dentistry. It is promising, highly precise, and safe bone cutting system that is based on ultrasonic

microvibrations which are optimally adjusted to target only mineralized tissue and spares soft tissue, nerves, and vessels. The precise nature of the instrument allows exact, clean, and smooth cut geometrics during surgery and this could be of great help in performing precise bone surgeries.

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