ISSN Print: 2394-7489
ISSN Online: 2394-7497
IJADS 2015; 1(5): 19-22
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www.oraljournal.com
Received: 05-10-2015
Accepted: 06-11-2015

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Piezosurgery: Ultrasonic bone surgery in periodontics and oral implantology- Review

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Abstract
Periodontitis is one of the chronic inflammatory disease of the tooth-supporting structures. The treatment of periodontitis is based on the removal of local factors and restoration of the bony architecture. Traditionally, manual or motor driven instrument are used to perform osseous surgery, but both have their own advantage and disadvantages. Recently, a novel surgical approach using the piezoelectric device is introduced in the field of periodontology and oral implantology.
The piezosurgical device provides extreme precision on micrometric cutting, safety as well as great control on the surgical site and the unit allowing one to selectively section the mineralized bone structures. Moreover, the device causes minimal bleeding during and after the operative procedure and the healing process is shorter.

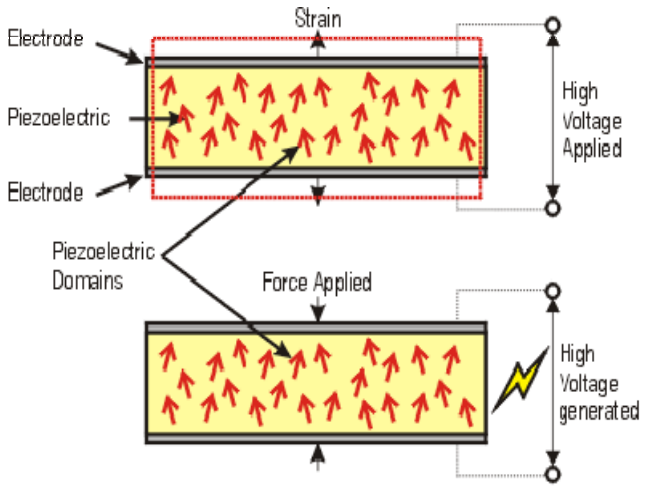
Keywords: Piezosurgery, osteotomy, osteoplasty, ultrasonic device

Introduction
Piezosurgery device is a sophisticated ultrasonic device, that can be used for bone surgery 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 trans positioning [1].
This device is designed to cut or grind the bone without damaging the adjacent soft tissues. The mechanism of this instrument is mainly based by the "Piezo effect".

History
- Piezoelectric effect was first described by French Physicist Jacques and Pierre Curie in 1880.
- Piezosurgery was first introduced by Dr. Tomaso Vercellotti in 1997 [2]
- First developed by Mectron (Italy) Medical Technology in 1998.

What Is Ultrasonics
Ultrasonics are branch of acoustics concerned with sound vibrations in frequency ranges above audible level-that is, greater than about 20 KHz. The term sonics is applied to ultrasound waves of very high amplitudes [3].
Production of Ultrasonics: can be by 3 different methods
1. Mechanical method: up to 100 KHz
2. Magnetostrictive system: 18-25 KHz
3. Piezoelectric system: 25-50 KHz

Piezo - Electric Effect
The word 'piezo' has been derived from the Greek word termed "piezein" which means to press or squeeze. In this, mechanical energy in the form of tension and compression is converted into electrical energy [4]. When opposite occurs i.e. Electrical energy (voltage) is converted into mechanical energy (tension and compression) it is called as Inverse Piezoelectric effect (Here voltage is in direct proportion to Force applied).



Mechanism

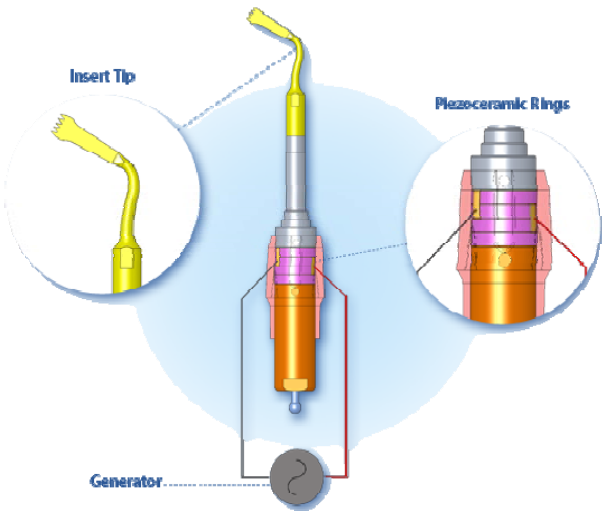
Piezoelectric crystals, commonly used are Rochelle salt, quartz, and certain types of ceramics.

Applying electrical charges to the face of a piezo electric crystals result in crystal compression, and by inverting the direction of electric charge, resulting in expansion. When the piezo electric crystals like quartz or ceramic disk is placed under an alternating electric field, it is possible to alternate between compression and expansion of the crystal thus producing a series of vibrations [4]

This will result in an oscillating shape change of the crystal at the frequency applied which is then passed onto the working tip.

When this series of vibrations are conducted through a piezoelectric transducer higher efficiency is obtained

The piezoelectric unit operates at frequency of 25-50 KHz. The resultant vibration produces the tip movement that is primarily linear in direction and generally allows only two sides of the tip to be active at any time. The device uses a specifically engineered surgical instrument characterized by a surgical power that is 3-times higher than normal ultrasonic instruments.



Application in Periodontology and Implantology

1. Scaling and Root planing: The piezosurgery device with a vibrating tip is used for removal of supra and subgingival debris, calculus and stains from teeth. Cavitation effect and microstreaming 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 [5].

2. Curettage: Piezosurgery device are used for the debridement of the epithelial lining of the pocket wall resulting in microcauterization. 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 [6].

3. Periodontal surgery: 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 interproximal bone defects. The mechanical action of ultrasonic micro vibrations, 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 [7].

Healing is improved by Piezo as it produces micro pits at the base of the defect to activate cellular response of healing mechanisms. It reduces the invasiveness of traditional surgery by making surgery faster and by ensuring thorough cleaning of the surgical site. It also favours tissue healing in the osteoplasty procedure.

4. Crown lengthening: The goal is to reposition the periodontal bone and soft tissues to a more apical position with appropriate biologic dimensions and minimal periodontal inflammation. 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 piezosurgery in direct contact with the root surface because control of the instrument during surgery is precise, even in very difficult proximity cases. The root planing phase can be performed very effectively using blunt ultrasonic inserts [8].

5. Harvesting Bone blocks and Bone grafting: The ultrasound device gives the possibility to collect autologous grafts in the form of bone chips or monocortical blocks. Bone chips as big as 500µm are the basis of osteoconductive bone regeneration. The piezo unit enables to gently scrub the bone surface to obtain graft material in sufficient amount. As far as bone blocks are concerned, the donor beds might be situated in the chin, iliac crest or oblique line of the mandible. Using this technique the easiness of the surgical procedure and smaller entrance site are guaranteed [9].

6. Block Harvesting Technique: Bone blocks harvested using traditional rotary cutting instruments to reduce the width of the cortical bone by at least 1 mm circumferentially and are unable to effectively cut the internal cancellous bone. So the block has to be detached using scalpels and this makes the margins irregular. Subsequently, it becomes necessary to further reduce the block width. Piezo surgery provides high precision and operating sensitivity and easy differentiation between cortical and cancellous bone while removing blocks of monocortical-cancellous bone [10].

7. Implant site preparation: As a new technique, implant site preparation can be performed with a specifically designed set of piezosurgical inserts. Piezosurgical site preparation allows for the selective enlargement of only one socket wall [11]. This is called ‘differential ultrasonic socket preparation’ by

Vercellotti. Piezosurgical site preparation provides similar primary stability and short-term survival rate of an implant when compared with conventional site-preparation techniques. Stelzle *et al*. [12] emphasized that the applied load on the handpiece may increase the preparation speed but it may also increase the negative thermal effect on the bone. Therefore, it is recommended that a maximum load of 400 g is used during implant site preparation.

8. Sinus lift procedure: In 2000, a new technique was developed that entails cutting an antrostomy (lateral window) using piezosurgery. This technique has greatly reduced the risk of membrane perforation (approximately 5% to 7%). Wallace *et al*, reported the perforation rate was reduced from the average of 30% with rotary instrumentation to only 7% with piezosurgery. Piezoelectric osteotomies cuts mineralized tissues without damage to the schinderian membrane. piezoelectric elevators to separate and raise the membrane easily without perforation. There is no risk of damage to the adjacent structures. Cavitation cleans the working area improving visibility [13, 14].

9. Tooth extraction: One of the main advantage of ultrasonic unit is the ability to prepare the bony window in the external cortex, which provides greater accessibility to the root or impacted tooth with limited loss of bone. Moreover, it enables one to replace the removed bony piece in its original position to improve the healing process and reduce the regeneration period [15].

Advantages

i. Micrometric cutting action: Precise incision with no damage to adjacent structures [16].
ii. Selective cutting action: sectioning does not damage the adjacent soft tissue [17].
iii. Cavitation effect: Maximum intra-operative visibility [18].
iv. Surgical stress: The cutting action is less invasive, producing less collateral tissue damage, which results in excellent tissue healing [19].
v. Asepsis: Sterile coolant provides an aseptic environment (free from contamination) [20] (6).

Disadvantages

The main disadvantage of the procedure using the piezosurgery unit is the increased operation time that is required for bone preparation [21, 22].

Heat produced during the piezosurgical procedures may be passed into adjacent tissues, adequate precautions must be taken to prevent damage to the adjacent tissues [23].

The use of irrigants is helps in cavitation and also to avoid overheating. The intensity of the cooling liquid can be adjusted depending on different preparations.

Cooling solution is used at 4 degree centigrade.

Conclusion

Piezosurgery is a new surgical technique for bone surgery with many clinical applications in dentistry. The advantages of piezoelectric bone surgery are low surgical trauma, exceptional precision, and fast healing response.

As a result, piezosurgery has the ability to increase treatment effectiveness while improving postoperative recovery and healing. It also has the potential to redefine the concept of minimally invasive surgery in osteotomy and osteoplasty procedures, thus replacing traditional systems.

Acknowledgements

Authors acknowledge the immense help received from the authors whose the articles are cited and included in reference of this manuscript. The authors are also grateful to authors/ editors/publishers of all those articles, journals, and books from where the literature for this article has been reviewed and discussed.

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