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Peizosurgery in Dentistry: A literature review

Dental Science

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ABSTRACT

The piezosurgery instrument, developed in 1988, uses a modulated ultrasonic frequency that permits highly precise and safe cutting of hard tissue. The selective and thermally harmless nature of the piezosurgery instrument results in a low bleeding tendency. The precise nature of the instrument allows exact, clean, and smooth cut geometries during surgery. Postoperatively, excellent wound healing, with no nerve and soft tissue injuries, is observed. Because of its highly selective nature, with its cutting effect exclusively targeting hard tissue, its use may be extended to more complex oral surgery cases, as well as to other interdisciplinary problems.

INTRODUCTION

Ultrasound has been used for many years in periodontics to remove tartar, debride root surfaces, and to degranulate periodontal defects. In the last decade a novel family of ultrasonic powered devices has been developed that is revolutionizing maxillofacial bone surgery. In 1997, TomasoVercellotti first introduced the idea to use an ultrasonic device for ablation fitted with a sharpened insert, such as a scalpel blade, to perform periradicular osteotomy to extract an ankylosed root of a maxillary canine. The implant positioned at the moment of the extraction worked perfectly and this gave rise to a series of experimental techniques using ultrasound for bone cutting.

The most compelling characteristics of piezoelectric bone surgery are low surgical trauma, exceptional control during surgery, and a fast healing response of tissues. Clinical studies have demonstrated that the specificity of operation and the techniques employed with piezoelectric bone surgery make it possible to advantageously exploit differences in hard and soft tissue anatomy. This not only increases treatment effectiveness but it also improves postoperative recovery and healing.

Ideally, surgical trauma should be minimized to obtain the optimal healing, which depends on gentle management of soft and hard tissues. Surgery, by definition, alters normal physiology by interrupting the vascular supply of tissues. The degree of surgical invasiveness is extremely important for the quality of tissue healing and may affect whether wounds heal by repair or regeneration. Indeed, when surgical trauma is kept to a minimum it generates enough stimulation to favor healing mechanisms that lead to regeneration. On the other hand, surgical techniques that are more traumatic often lead to greater inflammatory responses with slow healing that may lead to repair and scarring rather than regeneration. For this reason, it is desirable to choose the least traumatic surgical instruments and techniques for any surgical procedure. Piezoelectric bone surgery is conceived and developed precisely to overcome the limits of traditional bone cutting instruments and to achieve the most effective treatment with the least morbidity.

Birth Of Piezoelectric Bone Surgery

TomasoVercellotti carried out extensive scientific research in veterinary orthopedic surgery, which enabled him to determine the properties of ultrasonic cutting and obtain the first favorable results of tissue healing. He immediately understood the clinical importance of this new technology could have for all bone surgery; thus, he set up a research group with orthopedists, neurosurgeons, maxillofacial surgeons, and ear-nose-throat surgeons. In addition, encouraged by the research conducted on animals, began the clinical pioneering phase by developing new surgical protocols in oral, periodontal, and maxillofacial surgery, and by the invention of two new surgery techniques (Ultrasonic Implant Site Preparation and Orthodontic Microsurgery -New-Surgically-Guided Dental Movement). It was realized that a new bone discipline was arising with important clinical and histological features. In 1999, in order to distinguish it from traditional and insufficient ultrasonic bone surgery, it was decided to call it "Piezoelectric Bone Surgery".

This review article has been presented to provide a brief description of certain applications and the clinical benefits of piezoelectric bone surgery.

Characteristics Of Piezosurgery Surgical Instruments

The piezosurgery unit is composed of the main body, activated with a pedal, a handle, and number of inserts with different shapes depending on the surgical need.

Main Body

The main body has a display, an electronic touchpad, a peristaltic pump, one stand for the handle and another to hold the bag containing irrigation fluid.

The interactive touchpad has four keys that enable to select the feature mode, the specific program and the flow of the flowing cooling liquid. Every command is shown on the display.

There are two primary operating modes:

a. Bone Mode
b. Root Mode

Root Mode

The vibrations generated by selecting root mode are characterized by average ultrasonic power without frequency over modulation.

Two different programs:

a. **ENDO Program:** a limited level of power provided by applying reduced electrical tension to the transducer, which generates insert oscillation by a few microns. These mechanical microvibrations are optimal for washing out the apical part of the root canal in endodontic surgery.
b. **PERIO 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.

Bone Mode

The vibrations generated by selecting bone mode are characterized as follows: extremely high ultrasonic power compared to root mode. Its performance is monitored by several sophisticated software and hardware controls. 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 2:** for cutting low density spongy bone.

Special Program: was designed with a standard power level slightly lower than the bone programs and is characterized by the same frequency over modulation. The special program is dedicated to a limited series of surgical inserts that are particularly thin and delicate. The latter are recommended only for surgeons who have experience using piezosurgery and would like an extremely thin and effective cut.

Handle

The cutting action is based on the generation of ultrasonic waves by piezoelectric ceramic disks inside.

These ceramic plates are subjected to an electrical field produced by an external generator and vary their volume to generate ultrasonic vibrations. These are channeled into the amplifier, which transmits them to the sharp end of the handle. The insert is tightened with a special key for that purpose.

In this manner, the highest degree of efficiency is obtained for the cut and duration of the inserts.

Inserts

The design and features of all inserts used in Piezoelectric Bone Surgery have been conceived and developed by the Mectron Medical Technology.

The prototype of each specific insert was developed to satisfy the specific clinical needs of each surgical technique.

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.

Morphological-Functional Classification:

The morphological description defines the structural properties of the insert, while the functional description outlines the cutting characteristics:

- Sharp-Cutting
- Diamond-coated - Abrasive
- Rounded – Smoothing

Clinical Classification

The clinical classification sorts the inserts (sharp, abrasive, smoothing) according to basic surgical technique: osteotomy, osteoplasty, extraction.

1. Osteotomy (OT)- OT1 - OT2 - OT3 - OT4 - OT5 - OT6 - OT7 - OT7S4 - OT7S3 - OT8R/L
2. Osteoplasty (OP)- OP1 - OP2 - OP3 - OP4 - OP5 - OP6 - OP7
3. Extraction (EX)- EX1 - EX2 - EX3
4. Implant site preparation (IM)- IM1 (OP5) - IM2A - IM2P - OT4 - IM3A - IM3P
5. Periodontal Surgery- PS2-OP5-OP3-OP3A- Pp1
6. Endodontic Surgery- OP3-PS2-EN1-EN2-OP7
7. Sinus Lift- OP3-OT1 (Op5)- EL1 - EL2 - EL3
8. Ridge Expansion- OT7 - OT7S4 - OP5 (IM1) - IM2 - OT4 - Im3
9. Bone Grafting- OT7 - OT7S4 – OP1 - Op5
10. Orthodontic Microsurgery- OT7S4 - OT7S3

The inserts for basic osteotomy, osteoplasty, and extraction techniques are used in combi-nation with each other and with specific inserts in the surgical protocol for each technique.

Advantages

1. Micrometric cutting action
2. Selective cutting action: minimum soft tissue damage - ultrasonic frequency used does not cut soft tissue
3. Maximum intra-operative visibility (cavitation effect)
4. Minimum surgical stress - Excellent tissue healing .The cutting action is less invasive, producing less collateral tissue damage, which results in faster healing.
5. Sterile water environment for better asepsis (free from contamination).

Indications

Oral surgery

- Dental extraction,
- Third molar extraction
- Osteogenic distraction,
- Cyst removal
- Endodontic surgery,
- Bone harvesting (chips and blocks),

Implantology

Maxillary sinus lift

- Ridge expansion (crestal splitting),
- Alveolar nerve decompression,
- Harvesting techniques

Periodontology

- Crown lengthening technique.
- Resective and Regenerative Surgery

Orthodontic Surgery

- Osteotomy and Corticotomy.

Applications In Periodontology And Implantology

The removal of supra and subgingival calculus deposits and stains from teeth, periodontal pocket lavage with simultaneous ultrasonic tip movement, scaling, root planing and crown lengthening, periodontal ostectomy and osteoplasty procedures requires careful removal of small quantities of bone adjacent to exposed root surfaces to avoid damaging the tooth surface.[7] The piezosurgery device is used to develop positive, physiologic architecture of bone support of the involved teeth.

The piezosurgery device can be used for soft-tissue debridement to remove the secondary flap after incision through retained periosteum. By changing to a thin, tapered tip and altering the power setting, the piezosurgery device can be used to debride the field of residual soft tissue and for root surface scaling to ensure thorough removal of calculus. Osteoplasty and ostectomy is performed using the piezosurgery device to create positive architecture for pocket elimination surgery.[7] The device allows for precise removal of bone, with minimal risk of injury to underlying root surfaces. Final smoothing of root surfaces and bony margins using a specific ultrasonic insert, PP1, creates a clean field, with ideal bony architecture ready for flap closure. The piezosurgery device is used in bone grafting of an infrabony periodontal defect. Autogenous bone can be readily harvested from adjacent sites with minimal trauma and therefore minimal postoperative effects.[8] Implant site preparation, implant removal[9] and bone harvesting, bone grafting and sinus lifts can be done with much ease and less soft tissue trauma.

Conclusion

Piezoelectric devices are an innovative ultrasonic technique for safe and effective osteotomy or osteoplasty compared with traditional hard and soft tissue methods that use rotating instruments because of the absence of macrovibrations, ease of use and control, and safer cutting, particularly in complex anatomical areas.

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